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PREFACE

An initial attempt on the part of a large teacher-training institution to publish the results of its students' researches in the field of physical education comes to fruition with the appearance of the first *Monograph Supplement* published by the American Physical Education Association. Readers who have scanned the research literature in the fields of biology, physiology, psychology, and other sciences have become familiar with the frequent reference to supplementary issues of the various journals being consulted. Now a similar occasion to publish special noteworthy material, which could not have been included in the regular editions of the *Quarterly,* has been made possible in a profession which is just beginning to apply itself earnestly to a field literally teeming with fascinating but long neglected problems of research.

The first monograph supplement of the *Research Quarterly* has been made possible by the scientific interest, the enterprise, and the fine teamwork of the faculty and students of the University of Iowa. Thirteen researches of the students have been selected and edited for publication. The financing of the publication has been made possible in an interesting manner. The University of Iowa has contributed a share, through the Division of Physical Education, and each one of the students whose articles have been included has also made a contribution. In the concept of the plan, faculty members of the Department of Physiology and Physical Education have been most interested and helpful, particularly Dr. W. W. Tuttle, Director E. H. Lauer, Dr. C. H. McCloy, and Professor Elizabeth Halsey. Dr. Tuttle edited the studies which were carried on under the supervision of the various faculty members.

The new monograph, it is certain, will be but the beginning of similar ventures carried on by the schools that are now devoting themselves so well to research problems in our field.

Our progress in professional research is evident in many tangible ways. In 1927 there were four schools offering graduate work in physical education, and now there are thirty-one. In 1930, the *Research Quarterly* first made its appearance. In 1931, the Research Section of the A.P.E.A. made its first appearance at the A.P.E.A. Convention. This year the special monograph is issued. And what is more important, the number of research studies is not only increasing, but the quality of research is decidedly improving as workers in the field gain additional experience in research techniques, and have the advantage of a rapidly growing body of findings to consult and build upon.

Elmer D. Mitchell,
Secretary-Editor,

INTRODUCTION

It is with pleasure that I take this opportunity of adding a brief word of introduction to this publication of a group of monographs reporting work done at the University of Iowa. The papers may speak for themselves regarding the interest and scientific value of the contributions presented. Gratifying to a high degree for us at Iowa, must be a departmental relationship in which the stimulating effect of active intercourse between teacher and scholar, in laboratory and classroom, gives such evidence of thoroughly productive research. For all those engaged in the field of physical education as teachers and students, a publication such as this, the work of a group of young men and women eager and enthusiastic in their chosen field, can well be taken as further evidence that the work in physical education rests on a sound scientific basis of real scholarly endeavor.

Edward H. Lauer
Director, Division of
Physical Education

FOREWORD

THE studies, presented by Dickinson, Felker, Kistler, Schudel, and Kenefick and Denkmann, are compendiums of masters' theses in physical education, carried out in the laboratories of the Department of Physiology in the College of Medicine under the direction of the editor. The studies, presented by Grisier, Mitchell, and Lemon and Sherbon, are summaries of masters' theses in physical education, carried out under the direction of Professor Elizabeth Halsey. The study, presented by Reckmeyer, is an abstract of a master's thesis in physical education, carried out in the Department of Hygiene in the College of Medicine under the direction of Dr. A. V. Hardy. All theses are on file in the library of the State University of Iowa, Iowa City, Iowa.

The studies, contributed by Bresnahan and McCloy, are original investigations. The paper, presented by Bender, is a summary of the investigations dealing with the sprint.

I wish to acknowledge the able counsel so freely given by Dr. J. T. McClintock, Head of the Department of Physiology in the College of Medicine, during the course of many of the experiments and in the preparation of this monograph. Acknowledgment is herewith made to Coach G. T. Bresnahan for his cooperation in the experimental studies dealing with track events, to Coach C. Kennett for his assistance in the study dealing with golf, and to Dr. W. R. G. Bender for his aid in preparing the manuscripts for publication.

The work of Nakamura was translated with his permission.

W. W. TUTTLE

A Study of the Movement Pattern in Starting the Race from the Crouch Position

By George T. Bresnahan
Track Coach, State University of Iowa

IN THE crouching start a sprinter makes four contacts with the track when he assumes the "set" position. It was the object of this study to determine what the sequence was in breaking these contacts and to ascertain whether or not there was any procedure in this regard which was common to all trained sprinters.

TECHNIQUE

In order to record graphically the time when each contact was broken with the track, specially modified starting blocks and hand supports were devised. The way in which the starting blocks were modified has been described by Tuttle and Bresnahan.[1] The hand supports are shown in Figure 1. Each block consisted of two boards, 3/4" x 5½" x 8", hinged at one end. Two coiled springs were placed between the boards. A brass contact strip, one-half inch wide, was placed on top and all the way across the end of the top board opposite the hinge. Two copper contact catches, one on each side, were fastened to the bottom board so that they engaged the ends of the brass strip across the end of the top board. These hooks were so adjusted that, when the boards were pressed together, the distance between the brass strip and the contact catches was just sufficient to

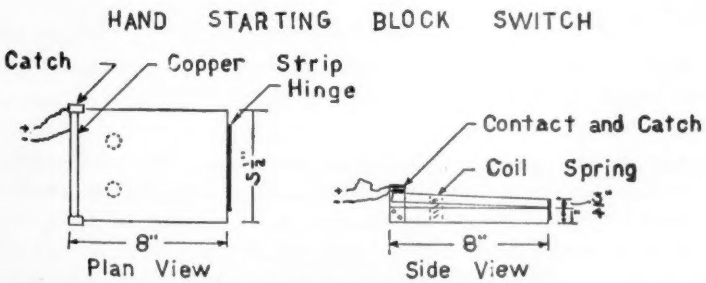

Figure 1.—The details of the hand starting block switch.

[1] W. W. Tuttle and G. T. Bresnahan, "An Apparatus for Measuring Starting Time in Foot Races," Research Quarterly, IV:2 (May, 1933), 110–116.

break contact. Both contact hooks were fastened together by a copper wire so that they served as a single switch.

The arrangement of the apparatus, for graphically recording the order in which the contacts with the track were broken, is shown in Figure 2. One of the hand block switches was placed in series with a dry cell and a signal magnet (4), while the other one was similarly connected to a signal magnet (5). In order to record the instant the gun was fired, a Dunlap sound key was placed in series with two dry cells and a signal magnet (1). The back starting block was placed in series with a dry cell and signal magnet (2) while the front starting block was in circuit with signal magnet (3). All five signal magnets were superposed to record on the smoked drum of an extension kymograph.

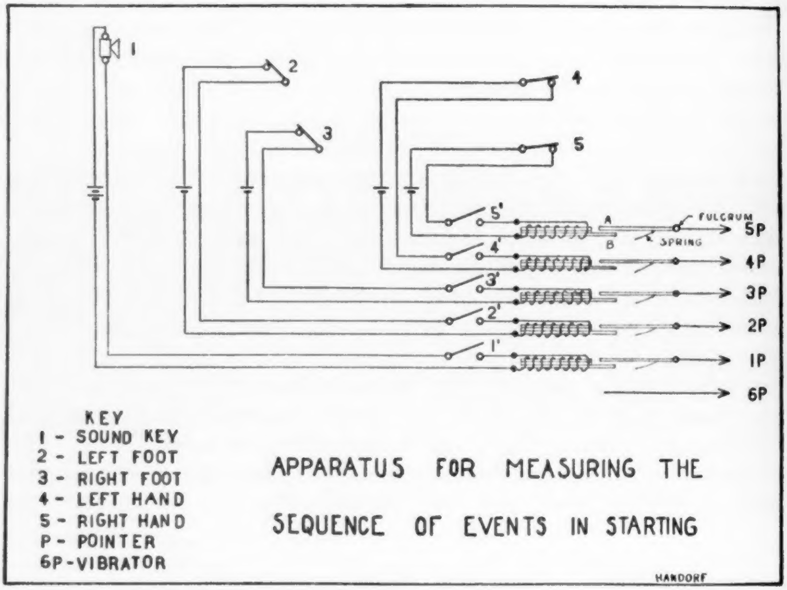

FIGURE 2.—The apparatus for recording the sequence with which the bodily contacts with the track are broken when a sprinter leaves his marks.

When all was in readiness the sprinter arranged the hand supports and starting block so that they were in proper relationship for a natural start. When the command, "on your marks," was given, the sprinter came to his natural position with his feet against the blocks and his hands on the supports. When the command, "get set," was given, the sprinter raised into the usual starting position. As he did, the body weight on his hands compressed the springs between the supports, thus opening the circuits. Likewise his weight against the starting blocks opened the cir-

cuits to them. All circuits were provided with knife switches which were kept open until the command, "get set," was given. An instant before the gun was fired, a signal was given to one experimenter who began spinning the kymograph drum. The sound of the gunshot activated the signal magnet (1, Figure 2). As the sprinter left his marks, the hand support and starting block switches were closed in the order in which the contacts with the track were broken, thus closing the signal magnet circuits. The closing of these circuits resulted in movement of the stylii, which indicated graphically the sequence in which the contacts with the track were broken.

In order to study time relationships an 100 d.v. electrically driven tuning fork (6P, Figure 2) was placed under the signal magnets' stylii. The speed of the kymograph was such that the distance from crest to crest, or trough to trough, of the tuning fork vibrations could be read in 1/100 seconds. Where the record of the break in the hand or foot block circuits fell between crest and trough, the time was read to 1/1000 place. It was important that all stylii were superposed since the kymograph was turned by hand and was, therefore, not constant.

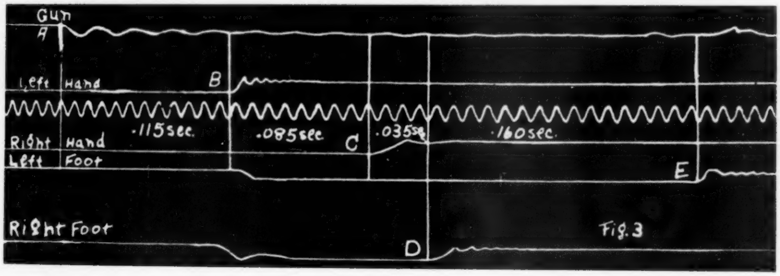

FIGURE 3.—This graphic record shows how the movement pattern in starting a race from the crouch position is determined.

A typical record is shown in Figure 3. In this record (A) indicates the time the gun was fired; (B) shows the time at which the left hand was lifted from the track; (C) is the point at which the right hand was started in motion; (D) represents the time of the removal of the right (back) foot from the block; (E) is where the left (front) foot disengaged the starting block. The wavy line between (B) and (C) is the tuning fork record. The record also shows the time required for the sprinter to break all the contacts. The wavy character of the signal line (A) was due to the continued vibration of the sound key. The first broken lines (D) and (E) were made when the sprinter raised into the "set" position, thus breaking the signal magnet circuits. It is obvious from Figure 3 that the graphic record obtained in the manner just described shows the sequence in which the contacts with the track were broken, the time

relationships between the breaking of the contacts, and the starting time of the sprinter. An analysis of this record revealed the following:

1. The sequence of breaking the contacts with the track was: left hand, right hand, right foot, and then left foot.

2. The left hand was raised from the track .115 seconds after the gun was fired; the right hand came up .085 seconds after the left; the right foot disengaged the block .035 seconds after the right hand was lifted from the track; the left foot broke contact with the block .160 seconds after the right.

3. The total time required for the sprinter to execute all the movements described was .395 seconds.

THE DATA

Data were collected from thirty-three trained sprinters. Twenty-eight of them were classified as right handed, and five of them left handed.[2] Each sprinter came to the laboratory and executed fifteen starts. Due to technical difficulties some of the records had to be discarded. However, there were never less than ten used for each subject.

Since the question of handedness appeared to be an influencing factor in the experiment, the data are presented on this basis.

Right-handed Group.—All twenty-eight of the right-handed subjects started with the right foot back. A summary of the data collected from this group is presented in Table I. Columns A, B, C, and D show the time elapsing between the firing of the gun and the beginning of the movements as indicated.

An examination of the raw data showed that in every start made by this group the sequence of movement was left hand, right hand, right foot, and then left foot. The mean times required for the execution of these movements were as follows:

a.	Left hand	.172 ± .003 sec.	Range	.122 to .220 sec.
b.	Right hand	.219 ± .003 sec.		.178 to .251 sec.
c.	Right foot	.286 ± .004 sec.		.207 to .350 sec.
d.	Left foot	.443 ± .005 sec.		.373 to .531 sec.

A further examination of the data revealed that, on the basis of means, the movement of the right hand followed that of the left very quickly, .047 ± .004 seconds, with a range of .003 to .086 seconds. Following the lifting of the right hand from the track, the right foot was moved from the block in .063 ± .004 seconds, with a range of .004 to .121 seconds. The left foot was moved from the block after the right .157 ± .006 seconds, with a range of .107 to .187 seconds. The total mean time required for getting off the marks was .443 ± .005 seconds, with a range of .373 to .531 seconds.

2 Handedness was determined on the basis of the more common bimanual and unimanual activities.

Left-handed Group.—Of the five remaining subjects one was purely of the left-handed type and four exhibited mixed behavior. As far as we were able to learn those who showed tendencies toward mixed handedness were for the most part originally left handed but had learned the use of the right hand in performing a part of their behavior.

TABLE I
THE SEQUENCE OF MOVEMENT OF RIGHT-HANDED SPRINTERS IN STARTING A RACE FROM THE CROUCH POSITION
(Time in 1/1000 Seconds)

Subject number	A Left hand	B Right hand	Right-left hand diff.	C Right foot	D Left foot	Right hand-Right foot diff.	Right-left foot diff.
1	209	268	59	350	477	82	127
2	170	201	31	254	441	53	187
3	183	219	36	265	430	46	165
4	161	218	57	289	427	71	138
5	182	185	3	298	452	113	154
6	196	248	52	299	458	51	159
7	165	251	86	278	418	27	140
8	137	178	41	259	413	81	154
9	174	218	44	320	484	102	164
10	180	253	73	313	492	60	179
11	151	202	51	323	436	121	113
12	198	219	21	279	404	60	125
13	167	227	60	256	473	29	217
14	172	235	63	271	446	36	175
15	144	218	74	252	408	34	156
16	212	264	52	276	452	12	176
17	199	224	25	273	450	49	177
18	140	181	41	323	430	42	107
19	181	217	36	320	489	103	169
20	173	220	47	280	425	60	145
21	176	214	38	271	391	57	120
22	176	233	57	327	531	94	204
23	122	200	78	246	415	46	169
24	147	203	56	207	416	4	209
25	182	208	16	318	476	110	158
26	138	194	56	260	391	66	131
27	156	208	42	263	373	55	110
28	220	248	28	348	494	100	148
Mean	172 ± 3	219 ± 3	47 ± 4	286 ± 4	443 ± 5	63 ± 4	157 ± 6

On the basis of the performance of the right-handed group one would expect a left-handed sprinter to start with his left foot back. The sequence of movement would then be right hand, left hand, left foot, and then right foot. It was interesting to note that the purely left-handed subject followed this sequence for each trial without exception.

Ambidextrous Group.—If one were to hazard a guess as to the

sequence of the movements of the ambidextrous individuals, it would, no doubt, be that he would follow no set order of movements in leaving his marks. A study of the data collected from the mixed-handed group showed this to be exactly the case. Subject seventeen started with his left foot back. Six times his right hand came up first, six times his left came up first, and twice both hands came up together. Subject twenty-four started with his right foot back. His right hand came up first six times, his left hand came up first seven times, and both came up together once. Subject one started with his right foot back. Six times his left hand came up first and eight times his right came up first. Subject fourteen, although seemingly predominantly left handed, started with his right foot back. In ten of his twelve starts his right hand came up first, while in two of them the left came up first.

These data showed that those, who were of the mixed type, used a variable sequence in starting.

DISCUSSION

This investigation brought out a number of points of interest, especially for those who are teaching the sequence of movements involved in leaving the marks in the sprints.

In the first place it should be noted that a sprinter followed a sequence of movements which was evidently purely reflex in nature in the same sense that walking is a reflex act. This was proved by the fact that if a right-handed or a left-handed man was correctly placed on his marks, he executed the proper sequence of movements without being taught.

A detailed discussion of handedness could not be included here even though we were capable of presenting it. However, the importance of handedness in starting the sprint from a crouch position is pointed out by this investigation. Before a candidate for sprinting instructions is placed on the marks his handedness ought to be known to determine whether or not the proper foot, in relation to handedness, is placed back. If by mere observation it is discovered that the hand movements are out of phase, the correct technique may be obtained by reversing the position of the feet. Should this fail, a correction of the improper sequence of movements may prove difficult, since changing handedness presents a difficult starting problem, just as it sometimes presents a difficult speech problem.

The importance of the proper sequence of movements in getting into stride is well known, and improper initiation of the arm movements is obviously a hindrance to the sprinter in getting off his marks. Any change which can be made to correct the improper initiation of the starting movements is, therefore, very useful.

It is the opinion of the writer that the sequence of movements as described in this treatise for right-handed and left-handed sprinters is the only correct form, all others being to the detriment of a sprinter in starting.

CONCLUSIONS

The following conclusions were drawn from the data presented:

1. The sequence of movements of a right-handed sprinter off his marks from a crouch position was as follows: left hand, right hand, right foot, and left foot.

2. The sequence of movements for a left-handed sprinter off his marks from a crouch position was as follows: right hand, left hand, left foot, and right foot.

3. The ambidextrous sprinter followed no regular sequence of movements in leaving his marks from a crouch position.

4. The sequence of movements described in (1) and (2) were reflex, and this sequence seems to constitute the correct pattern for leaving the marks from a crouch position.

The Effect of Foot Spacing on the Starting Time and Speed in Sprinting and the Relation of Physical Measurements to Foot Spacing

By A. D. Dickinson
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PERSONAL communications with coaches and a survey of the texts in the field of coaching substantiated the fact that there was no general agreement as to the best foot spacing for a sprinter to assume in starting a race. Where recommendations were made there was usually little more than subjective evidence to support them.

REVIEW OF LITERATURE

Hjertberg*[1] recommends that the foot front should be four inches back of the starting line and the foot back so placed that the knee on the ground is even with the front of the arch of the foot front. Robertson[2] states that the foot front should be six to nine inches behind the starting line and the foot back, the length of the leg back of the foot front. Bickley[3] believes that the foot front should be placed as near the starting line as possible and the foot back placed so that the knee is even with the arch of the foot front. In discussing the foot spacing of a sprinter at the start of a race, Gill[4] recommends that the foot front should be twelve inches behind the starting line and the knee of the leg back even with the ball of the foot forward. Hahn[5] states that the distance between the starting line and the foot front depends on the size of the man but that this distance is usually six to eight inches. The position of the foot back should be such that the knee is even with the instep of the foot front, in the kneeling position. Wegener[6] states that the foot front should be placed four to six inches behind the starting line. The foot back should be placed so that the knee of the leg back is almost even with the arch of the foot front, in the kneeling position. Jones[7] recommends three types of starts, depending on the size of the man. For the small man the "bullet" or "Drew" start is advised. In this type, the foot front is eighteen and the foot back thirty inches from the starting line. For the average man a "normal" start is used. In this case, the foot front is twelve and the foot

* Numbers refer to bibliography at end of article.

back thirty-four inches from the starting line. For the tall man, the "regular" start is recommended. Here, the foot front is six to ten inches from the starting line. The knee of the foot back is even with the ball of the foot front, in the kneeling position. Butler[8] favors placing the foot front the shoe length from the starting line with the knee of the foot back even with the heel of the foot front. The individual height should be a deciding factor. Frymir[9] recommends placing the foot front five to six inches behind the starting line, with the knee of the leg back even with the heel of the foot front, the leg length being a determining factor. According to Olds[10] the foot spacing should be determined by the length of the leg. However, in general he places the foot front six to eight inches back of the starting line and the foot back so that the knee of the leg back is opposite the arch of the foot front when a kneeling position is assumed.

The striking point about the literature dealing with foot spacings in the start of the sprint is the lack of agreement as to just what these spacings should be. No doubt the opinions reviewed are based on wide experience, yet they vary greatly. Certainly all sprinters have a common goal in adopting foot spacing, and that is to select the one which is the most conducive to a fast start.

Since there appeared to be diversity of opinions relative to the problem of foot spacings in the start of the sprint, the writer felt that some definite ideas might be established on this point if the question were attacked experimentally.

TECHNIQUE

DEFINITION OF STARTING TIME

The difficulty in defining starting time has already been discussed by Tuttle and Bresnahan,[11] Hayden and Walker,[12] and Walker and Hayden.[13] These investigators defined starting time as the interval elapsing between the gunshot and the breaking of the contact with the foot back. For the purpose of this experiment it was necessary to redefine starting time. In the experiments referred to above, the individual foot spacing was not a variable but was kept constant, while in the present investigation the foot spacing was the variable. For this reason starting time was redefined as the time elapsing between the gunshot and the breaking of the contact by the foot front.

DEFINITION OF THE TYPE OF STARTS USED

There were four different types of starts used, as follows:

A. *Elongated Start.*—A position in which the knee of the leg back is opposite the heel of the foot front in a kneeling position.

B. *Medium Start.*—A position in which the knee of the leg back is opposite the front of the arch of the foot front in a kneeling position.

C. *Bunch or Bullet Start.*—A position in which the toe of the foot back is opposite the back of the heel front in a "standing" position.

D. *Natural Start.*—A position which a sprinter was accustomed to and which seemed most natural to him.

The foot spacing was the controlled variable. Uniformity was maintained for all types of foot spacing, but no suggestions were made as to the position of the arms, hands, and back. The position of the foot front from the starting line was left to the judgment of the sprinter. The position actually assumed by the sprinters in the "set" was one in which the hip-shoulder plane was parallel with the ground, the knee of the leg back being slightly higher than the ankle, and the thumb and forefinger forming an arch on the starting line, except in three cases where the hips were higher than the shoulders.

APPARATUS FOR MEASURING STARTING TIME

The apparatus for measuring starting time has been described in detail by Tuttle and Bresnahan.[11] In general, it consisted of an electrically driven chronoscope so arranged that the firing of a gun started it, and a contact made by the sprinter when he left his marks stopped it. Starting time was read in sigma (thousands of a second).

APPARATUS FOR MEASURING SPEED IN SPRINTING

The distance over which a sprinter was timed was seven and one-half feet, an arbitrarily selected distance, but a distance that unquestionably fell within the range of acceleration.

At seven and one-half feet from the starting line a finish yarn was stretched across the track, one end of which was attached to a spring switch, so that when stretched across the track the switch was held open. The other end of the yarn was attached to a hook, so beveled that the slightest touch of the yarn caused it to unfasten and allowed the spring switch to make contact.

The chronoscope was used to measure time. The firing of the gun started it, and the making of the contact by the spring switch stopped it. The interval of time between the events was considered as sprinting time for seven and one-half feet.

PHYSICAL MEASUREMENTS

A. *Height.*—Standing height in inches, shoes off.

B. *Trunk Length.*—The distance in inches from the seventh cervical vertebra to the seat of the chair, the subject sitting in erect position.

C. *Arm Length.*—The distance from the acromium process to the ground in the kneeling position, with the thumb and forefinger forming an arch on the starting line.

D. *Weight.*—Stripped weight in pounds.

E. *Leg and Thigh.*—From the head of the femur to the ground in the standing position.

POSITION OF THE FEET

In each position starting blocks were used. The lateral distance between the feet ranged from five to seven inches. For each type of start the distance between the feet was kept constant for each subject. The antero-posterior position of the feet which the sprinter assumed was determined by measuring the distance of both feet from the starting line, resulting in a measurement that represented the distance between the feet.

THE DATA

THE EFFECT OF FOOT SPACING ON STARTING TIME

Twenty-six trained sprinters served as subjects, each of which made thirty-two starts upon three occasions, totalling ninety-six starts for each subject.

For each subject each type of start was used. The starting positions were alternated in such a way as to reverse the order of previous rotation, thus preventing the element of fatigue or the warm-up phase from being modifying factors.

Table I is a summary* of the data collected from the twenty-six subjects on the relationship between types of starting positions and time elapsed between the gunshot and the front foot breaking contact. The data showed that, on the basis of the means of each subject, the starting times were faster when the bunch start was used. In every case, except four, the bunch start yielded the fastest starting time. In these four cases, the natural start yielded the fastest time, but when the individual cases were examined, their natural start, in each case, was more extreme than the bunch start, i.e., the antero-posterior distance between the blocks was less. In every case when the elongated start was used the slowest starting time was made; in every case when the medium start was used the starting time fell between the starting time of the elongated start and that of the bunch start, and was slower than the mean starting time of the bunch start.

RELATIONSHIP BETWEEN THE TYPE OF START AND THE RUNNING TIME FOR SEVEN AND ONE-HALF FEET

Since the use of the bunch start resulted in the fastest starting time, the question arose as to whether or not a fast start was conducive to a faster time for covering a short distance after the start. The time elapsing

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* Complete tables and raw data are omitted but are on file in the library of the State University of Iowa: A. D. Dickinson, A Study of the Relationship Between Foot Spacing, Starting Time, Speed in Sprinting, and Physical Measurements, M.A. Thesis, June 1933.

between the gunshot and the instant a sprinter broke the tape at a point seven and one-half feet distant was compared with the type of start used. Ten sprinters served as subjects.

TABLE I

A COMPARISON OF STARTING TIME FROM THE STARTING POSITIONS AS INDICATED INCLUDING A SUMMARY OF THE MEANS FOR ALL SUBJECTS IN EACH POSITION

Subject	Type of Start			
Number	Elongated *sigma*	Medium *sigma*	Bunch *sigma*	Natural *sigma*
1	403 ± 1.8	348 ± 5.6	242 ± 3.9	224 ± 3.7
2	371 ± 5.2	298 ± 2.6	223 ± 3.4	
3	435 ± 7.4	353 ± 5.8	266 ± 4.5	301 ± 5.3
4	378 ± 3.8	314 ± 5.8	233 ± 2.9	279 ± 5.9
5	360 ± 5.2	258 ± 3.6	253 ± 2.5	229 ± 3.2
6	453 ± 3.9	439 ± 4.7	261 ± 3.5	386 ± 7.3
7	379 ± 4.4	291 ± 5.6	240 ± 4.3	288 ± 7.7
8	351 ± 3.4	288 ± 6.4	221 ± 4.1	291 ± 6.3
9	468 ± 3.8	358 ± 4.9	269 ± 5.3	297 ± 7.9
10	408 ± 3.7	332 ± 4.2	229 ± 5.1	263 ± 6.9
11	388 ± 4.5	326 ± 3.9	238 ± 3.7	245 ± 5.6
12	371 ± 5.5	357 ± 4.2	258 ± 4.0	321 ± 3.7
13	375 ± 2.7	272 ± 3.5	234 ± 3.7	265 ± 2.8
14	433 ± 6.1	350 ± 4.4	283 ± 4.5	315 ± 5.1
15	375 ± 5.8	328 ± 2.5	248 ± 4.5	218 ± 2.3
16	372 ± 6.2	276 ± 4.4	219 ± 3.2	295 ± 5.6
17	396 ± 5.7	324 ± 6.4	244 ± 4.4	
18	367 ± 5.3	320 ± 6.4	242 ± 4.8	283 ± 2.5
19	415 ± 5.1	346 ± 5.2	242 ± 5.2	286 ± 6.9
20	376 ± 6.0	335 ± 6.1	266 ± 7.2	304 ± 7.1
21	379 ± 6.9	320 ± 4.5	249 ± 6.2	301 ± 4.8
22	373 ± 2.9	301 ± 5.6	235 ± 3.8	
23	408 ± 7.7	347 ± 6.2	235 ± 3.7	247 ± 5.1
24	395 ± 5.3	303 ± 6.8	232 ± 4.8	223 ± 4.4
25	397 ± 3.2	350 ± 7.9	270 ± 5.9	
26	287 ± 4.0		210 ± 2.1	
Means	387 ± 5.6	326 ± 4.8	244 ± 2.1	280 ± 4.5

Table II is a summary of the data collected. When the bunch start was used, the mean times, as compared with those when the elongated or medium starting positions were used, in every case were shortest. The use of the elongated start resulted in the slowest times for covering the distance.

RELATIONSHIP BETWEEN PHYSICAL MEASUREMENTS AND POSITION OF THE FEET

Of the twenty-six subjects, sixteen, the eight shortest and the eight tallest, subjects were used for making these comparisons. The average

height of the short men was five feet, eight inches, and for the tall men, six feet, one inch, a difference of five inches.

The mean trunk length of the tall men was 29 inches, for the short men 27 inches; the mean arm length of the tall men was 29 inches, for the short men 27 inches; the mean leg and thigh length of the tall men was 39 inches, for the short men 34 inches; and the average weight of the tall men was 168 pounds, of the short men, 145 pounds.

TABLE II

A Comparison of Sprinting Time from the Starting Positions for Seven and One-half Feet Including a Summary of the Means for Ten Subjects in Each Position

Subject	Type of Start		
Number	Elongated *sigma*	Medium *sigma*	Bunch *sigma*
1	894 ± 1.7	915 ± 6.2	872 ± 7.7
2	926 ± 6.6	950 ± 5.8	853 ± 6.5
3	860 ± 4.1	846 ± 4.6	782 ± 9.2
4	886 ± 5.1	879 ± 6.2	817 ± 5.9
5	861 ± 6.0	809 ± 6.3	722 ± 8.7
6	935 ± 8.4	927 ± 7.3	845 ± 4.4
7	956 ± 6.8	889 ± 8.3	809 ± 9.9
8	877 ± 6.0	862 ± 6.9	800 ± 7.5
9	867 ± 5.9	850 ± 5.7	792 ± 6.3
10	842 ± 5.9	844 ± 6.3	807 ± 4.6
Means	887 ± 6.4	878 ± 8.5	806 ± 5.5

For the elongated, medium, and bunch starts the mean distance of the foot front from the starting line was, for the tall men, fourteen inches, sixteen inches, and twenty-one inches, respectively, and for the short men, eleven inches, thirteen inches, and eighteen inches, respectively. For the elongated, medium, and bunch starts the mean distance of the foot back from the starting line was, for the tall men, forty-two inches, thirty-seven inches, and thirty-two inches, respectively, and for the short men, thirty-seven inches, thirty-three inches, and twenty-eight inches. Irrespective of the type of starting position the foot front of the tall men was, on the average, three inches farther back from the starting line; and the foot back of the tall men was, on the average, five inches, four inches, and four inches farther back from the starting line than the foot back of the short men, for the elongated, medium, and bunch starts, respectively.

In general, the data on the physical measurements for the whole group showed that in the various starts the taller the man the farther back from the starting line he set his block front, regardless of the type of start used; similarly for the block back, the determining factor being

the height of the man. The difference in distances between the blocks of the three starting positions for the tall as compared with the short men was small since by definition the determining factor was the size of the foot.

SUMMARY AND CONCLUSIONS

Data were collected from twenty-six experienced men in an effort to determine whether or not the spacing of the feet had any effect upon the time required for them to leave their marks. Data were collected from ten men to determine whether foot spacing had any effect upon the time required for them to cover a distance of seven and one-half feet, a distance in which the sprinter was in full stride. In addition, data were obtained from sixteen men to determine the relationship between the physical measurements and the position of the feet.

A comparison of starting time where the elongated, medium, bunch, and natural starts were used showed that:

1. The use of the bunch start resulted in significantly fastest starting time.
2. The use of the elongated start resulted in the slowest starting time.
3. The use of the medium start resulted in a starting time which fell between that of the bunch and the elongated starts.

A comparison of times, of ten subjects, elapsed between gunshot and the running of seven and one-half feet, when the elongated, medium, and bunch starts were used, showed that:

1. When the bunch start was used the time it took to cover the distance in every case was significantly less than the time it took when the other starting positions were employed.
2. The use of the elongated start resulted in the slowest time for the distance.
3. The use of the medium start resulted in a time which fell between those of the elongated and bunch starts.

A comparison of the physical measurements with the position of the feet for the eight tall and the eight short sprinters showed that:

1. The distance behind the starting line that a sprinter placed the block front depended upon the height of the individual, irrespective of the type of start used. For example: the five-foot, eight-inch man placed the block front from the starting line eleven inches, thirteen inches, and eighteen inches, for the elongated, medium, and bunch starts respectively; and the six-foot, one-inch man, fourteen inches, sixteen inches, and twenty-one inches.
2. The distance behind the starting line that a sprinter placed the block back, depended upon the leg and thigh length of the individual, irrespective of the type of start used, being materially greater for the tall men. For example: the five-foot, eight-inch man placed the block back from the starting line thirty-seven inches, thirty-three inches, and

twenty-eight inches, for the elongated, medium, and bunch starts respectively; and the six-foot, one-inch man, forty-two inches, thirty-seven inches, and thirty-two inches.

3. The distance between the starting blocks of a tall or a short man was small, and only slightly greater for the tall man, since the size of the foot was the determining factor, by definition of the starting positions. For example: the distance between the blocks for the five-foot, eight-inch man was twenty-six inches, twenty inches, and ten inches for the elongated, medium, and bunch starts, respectively; and for the six-foot, one-inch man, twenty-eight inches, twenty-one inches, and eleven inches.

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A Study of the Respiratory Habits of Sprinters in Starting a Race

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SINCE respiration is a physiological process which automatically meets the demands made upon the body, it is ordinarily unnecessary to give it any attention in situations where exercise is involved. However, in some activities it is generally recognized that efficiency can be facilitated by a voluntary control of the respiratory mechanism. Swimming is an example of a sport in which voluntary respiratory control is important.

Respiration when considered from the standpoint of starting the sprint seems to concern itself not only with the question of ventilation but also attention. Sizing up opponents, anticipation of the gunshot, a feeling of "setness" on the marks—all involve attention; and the question arises, "Does the sprinter exhale, inhale, or disregard respiration between getting on the marks and starting when the gun is fired?"

REVIEW OF LITERATURE

No experimental approaches to the problem of the respiratory habits of sprinters have been made. However, some track authorities have prescribed certain practices. Jones*[1] states that just prior to the pistol shot a sprinter should take a long, deep breath and should hold it. Jones[2] states that a few deep breaths should be taken before getting on the marks and that breathing during the sprint should be natural. Wegener[3] states that ten minutes should be spent in deep breathing before getting on the marks and at the command, "get set," the breath should be held and ejected after the second stride. Gill[4] recommends deep breathing beforehand, and inhalation after the command "on your marks." Robertson[5] recommends that a runner take a fairly deep breath while getting "set." Paddock[7] states that breathing should be natural before getting on the marks and that a deep breath should be taken while getting "set."

The purpose of this investigation was to study the respiratory habits of sprinters during the start of a race in order to determine, if possible, the habits most conducive to a good start.

* Numbers refer to bibliography at end of article.

TECHNIQUE

For the purpose of recording respiratory movements the technique employed by Schudel was used.† This technique involved the use of an ordinary respiratory mask which was placed over the face and attached to a recording tambour. On inspiration, air flowed in through the open side of the mask. During an inspiration the pressure in the air line to the tambour was reduced, and this reduction of pressure caused the recording lever to be pulled down. On expiration, the pressure in the air line to the tambour was increased, which increase in pressure moved the recording lever upward.

When ready for a record, the mask was adjusted to the face of a sprinter prior to getting on his marks, and as soon as the sprinter was on the marks, the kymograph was started at a relatively fast speed. The movements involved during respiration were thus recorded from the time the command, "on your marks," was given until the sprinter left his marks. The signals, "on your marks" and "get set," were recorded on the kymograph by means of a signal magnet, the switch of which was held by the starter. The gunshot activated a signal magnet which was also recorded on the kymographic record. Time was recorded in fifths of a second by means of a Jaquet chronograph.

The investigation was carried out on an experimental track which very closely resembled the ordinary indoor track, and all conditions simulated those which a sprinter experiences in a competitive race.

Although the starting times of the groups studied were measured this discussion will be confined to respiration.

THE DATA

Twenty-four trained and six untrained sprinters served as subjects. From one sprinter, records were obtained during a season of training.

Respiratory Movements of the Trained Sprinter.—Each sprinter came to the laboratory once or twice to determine, by his starting times, whether he could be classed as trained or not. Twenty-four subjects served. The subjects were totally unaware of the nature of the data collected for the question of respiration was not discussed with them. Typical records are shown in Figure 1. Inspiration is indicated by the downward stroke of the tambour stylus and expiration by the upward stroke. In this figure, the command, "on your marks," was given at *A*, "get set" at *B*, and *C* indicates when the gunshot occurred. An examination of the records revealed the fact that there are certain tendencies characteristic of all. Between the commands, "on your marks," and "get set," respiration, as shown by the figure, was quite normal. Slight disturbances (see records *B* and *C*, Figure 1) in some records indicated

† H. Schudel, "A Study of the Respiration of Golfers During the Drive and the Putt," University of Iowa Studies in Physical Education, No. 1, 1934. Published by the American Physical Education Association, Ann Arbor, Michigan.

adjustments made by a sprinter in position. As a rule, however, the breathing occurred in a normal manner.

From Figure 1 it can be seen that as soon as the command, "get set," was given, the sprinter finished the phase of normal breathing, inhaled,

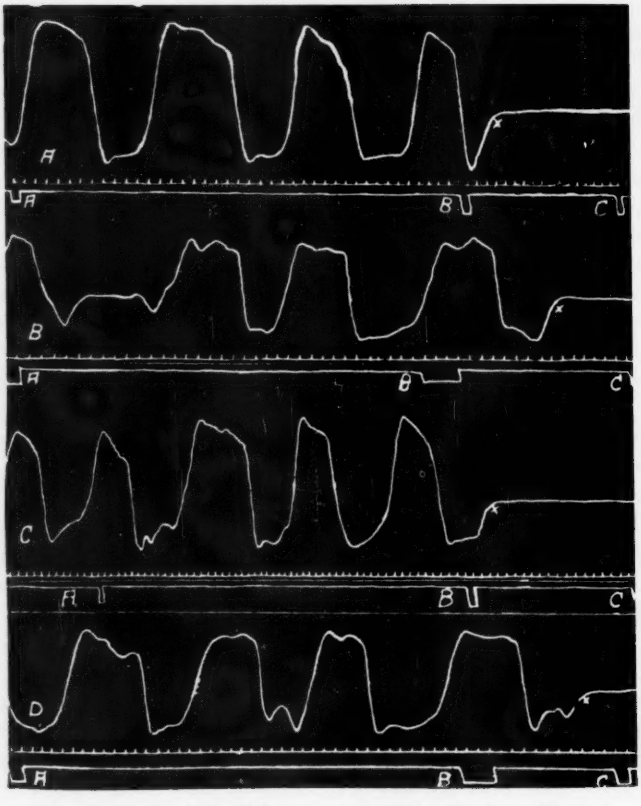

FIGURE 1.—Records of the respiration of trained sprinters.

and held his breath (x, Figure 1), a position which was quite constant until the gun was fired and the sprinter left his marks. The slight rise in the stylus, after the point at which the breath was held, is a return to the baseline due to an equalization of pressure in the tambour. This command, "get set," came, as indicated, in Figure 1, in case A, near the end of inspiration—inspiration was completed and the breath was held; in case B, at the beginning of expiration—expiration was completed followed by a full inspiration and the breath was held; in case C, at end of inspiration—the breath was held; and case D, during expiration—expiration was completed, inspiration initiated and completed, and the breath was held.

After the command, "get set," was given, in every case the respiratory adjustment for holding the breath was made at the end of the inspiratory phase, regardless of the phase which was being executed at the time of the command.

Whether the tendencies of the trained group, regarding respiratory action during the start of the sprint, were natural or acquired was checked by examining untrained sprinters.

Respiratory Movements of the Untrained Sprinters.—Six served as subjects for this investigation. On the basis of starting times‡ these men were classed as untrained. Two of the untrained group showed in their records a tendency to hold the breath, while four did not. Figure 2 shows two typical records of the respiratory movements of this group. Both *A* and *B* are records of those that did not hold their breath after the command, "get set," the breathing being quite normal throughout the start.

The Effect of Training on the Respiration of a Sprinter.—The lower two records, *C* and *D*, of Figure 2, represent the breathing pattern of a sprinter who was observed during the training season. Records were taken intermittently throughout the track season. Record *C*, Figure 2, shows the respiratory movements in early season, revealing that this sprinter breathed quite naturally throughout the start of a race. Record *D*, Figure 2, was obtained six weeks after the beginning of the training period. This is an example of the respiration of a trained sprinter. At the command, "get set," which came at the end of inspiration, the breath was held until after he left the marks.

DISCUSSION

From the physiological standpoint the question of respiration during the start of the sprint is a dual one. From an examination of the various treatises on starting the sprint, it was evident that, where the question of respiration in relation to the sprint was discussed, it was usually spoken of from the standpoint of adequate preparation for proper ventilation during the run to be executed. The present investigation throws no light on the question of proper ventilation for a race.

The examination of various treatises also brought out the fact that it was strongly suggested that the respiratory habits of trained sprinters during the start of a race were acquired, not as a means of preparation for the course of the race, but as an important phase in their adjustment for bringing their attention to a peak when the gunshot meant the start of a race.

That attention is an important factor in starting a race is generally

‡ Defined in paper by A. D. Dickinson, "The Effect of Foot Spacing on Starting Time and Speed in Sprinting and the Relation of Physical Measurements of the Sprinters to Foot Spacing," UNIVERSITY OF IOWA STUDIES IN PHYSICAL EDUCATION, No. 1, 1934. Published by the American Physical Education Association, Ann Arbor, Mich.

conceded. There is considerable evidence that holding the breath is a part of the adjustment for "paying" maximum attention. Gaskill[8] suggested that simple reaction time was influenced by the phases of respiration. He also stated that a person held the breath when making a difficult

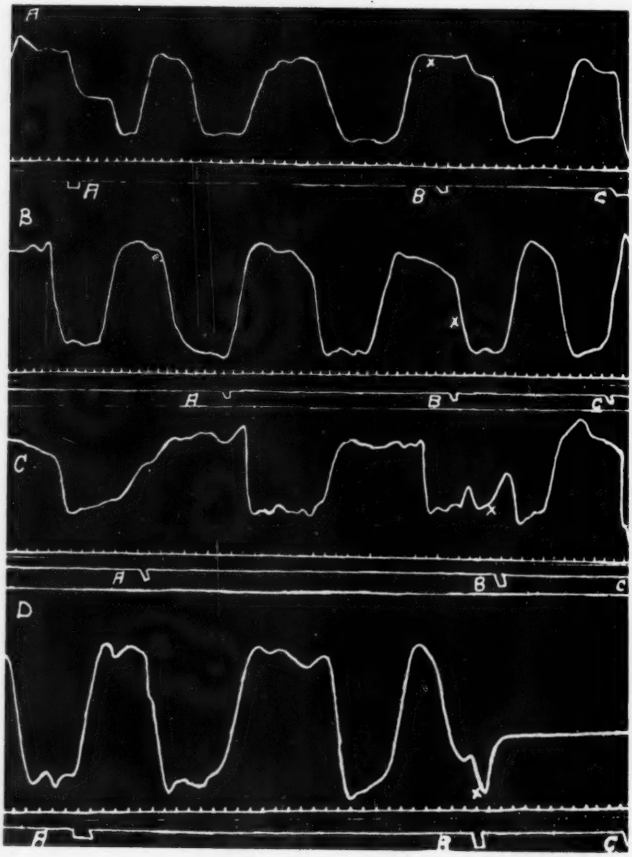

FIGURE 2.—Records *A* and *B* show the respiratory pattern of untrained sprinters. Record *C* is an early training season record of the breathing pattern of a beginning sprinter. Record *D*, same as *C*, except later in the training season.

sensory discrimination, and that on the rifle range the customary procedure was to take a deep breath, to exhale slightly, and then to hold the breath while aiming and firing. According to our findings, the behavior of the trained sprinter in the start of a race paralleled this behavior.

Cowan[9] proved that where a precision movement was being made, a synchronization of the inspiration-expiration phases with the move-

ment materially increased its accuracy. Our own investigation, when compared with the others, reinforced the idea that the respiratory habits of sprinters during the start were related to the process of attention.

The trained sprinters were not taught to hold the breath during the start of the sprint but acquired the habit on their own accord during training. In the case of the individual whose breathing habits were recorded intermittently during training season, the breath-holding habit was acquired, although this procedure was not mentioned to him as a part of his training.

SUMMARY AND CONCLUSIONS

Data, relative to respiratory movements during the start of a race, were collected from a group of twenty-four trained and six untrained sprinters. The respiratory movements of one untrained sprinter were studied during the training season. An analysis of the records of breathing during the start of a race resulted in the following conclusions:

1. Trained sprinters breathed normally between the commands, "on your marks" and "get set." At the command, "get set," they completed the phase of respiration which was being made, took a normal breath of air, and held it until after the gun was fired. If the command, "get set," was given during, or at the beginning of, expiration, the phase was completed, and was followed by a normal inspiration. If the command occurred during inspiration, this phase was completed. In other words, irrespective of what respiratory phase was going on, the "set" adjustment in respiration was always made at the end of an inspiration.

2. As a rule, the untrained sprinter breathed normally straight through the start, from the command, "on your marks," until the gun was fired and the sprinter left his marks. Where a respiratory adjustment occurred, it was comparable to that made by a trained sprinter.

3. The holding of the breath by a sprinter during the "set" period was acquired naturally, through practice in starting, and without having attention called to it.

4. In the start of the sprint there are two aspects of the physiological process of respiration: (a) ventilation preparatory to running a certain distance, and (b) adjustment (holding the breath) concomitant with the process of attention. It is suggested at this time that holding the breath while waiting for the gunshot is a natural adjustment which is similar to any adjustment man makes while "paying" maximum attention to something, and is not a phenomenon peculiar to a sprinter in the "set" position.

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A Study of the Distribution of the Force Exerted Upon the Blocks in Starting the Sprint from Various Starting Positions

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ONE OF the points related to starting the sprint which is of interest is that having to do with the distribution of the driving force off the blocks. The opinions of the coaches relative to this point vary from one extreme to another. Some contend that the major part of the drive-off is with the leg back, others that it is with the leg front, and still others believe that it is equally distributed between the two legs. So far as we have been able to find, all of the opinions relative to this point are based upon general observation and subjective evidence.

In order to get a true picture of what actually occurs, a laboratory experiment yielding objective data appeared to be necessary. The purpose of this investigation was to determine the force exerted by each leg in various starting positions with the hope of throwing some light upon the question of distribution of driving force.

REVIEW OF LITERATURE

The most significant fact revealed through an examination of the literature relating to this question is that no reports of an experimental approach to the problem were found. However, many track coaches have expressed their views relative to the matter of the proper leg drive in the start, and some have stated their views in the books that they have written.

Frymir*[1] says that the push-off in the start should be with the leg front. Olds[2] believes that the drive should be with the leg back. Wegener[3] holds that the pressure should be exerted with both legs. Gill[4] advocates driving off with the leg front. Robertson[5] says that in starting, no pressure should be put on the back foot and that an effort should be made to get the foot out and down as quickly as possible. Hjertberg[6] would have the starter place no weight on the leg back so that it is free to exert the most of the push-off.

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* Numbers refer to bibliography at end of article.

TECHNIQUE

The technique involved in measuring the force exerted in the drive-off in starting the sprint presented many difficulties. The one of major importance was that related to the maintenance of a steady base from which the drive was made. It was very difficult to measure the force exerted without having the sprinters start from blocks which move when the drive is exerted against them. In the technique described this difficulty was not overcome entirely but was reduced to a minimum.

Apparatus for Measuring the Drive.—The apparatus involved in this experiment consisted of a pair of spring scales remodeled so as to meet the requirements of this investigation. The first objective to be attained in the set-up was the regulation of the movement of the scale pan when force was exerted against it. In order to accomplish this end, two additional springs were placed in each set of scales, thereby increasing the resistance so that the maximum force exerted by a sprinter did not move the scale pan more than one-half inch. This addition of springs necessitated a recalibration of the scales. This was done for each interval of ten pounds, the weights between being interpolated. This interpolation was reliable since the recalibration showed the response of the springs to be represented by a straight line within the limits permitted by the scale leverage. The figures presented are all corrected to the new calibration made necessary by the addition of the extra springs.

In order to record the movement of the scale pan when force was applied to the scale, a celluloid covering was placed on the face of the dial and a pencil attached to the scale hand so that when the hand moved, the pencil traced the path of movement on the celluloid covering. After the response was completed the extent of the excursion of the dial hand was shown by the mark on the dial covering and thus the reading was easily made. After each response the mark was erased by the use of cotton, in preparation for the next start. The reading was made in terms of the uncorrected dial numbers and multiplied by the correction.

Starting blocks were attached to the scales in place of the scale pans. The two sets of scales were modified and fastened to a frame in the track so that the antero-posterior distance between the blocks could be varied. The scales were also arranged so that the angle of the starting block could be controlled. The back one was placed at an angle of a little less than 90 degrees while the front block was maintained at an angle of 45 degrees. When the scales were in place the bottom of each starting block was flush with the track and, due to the angle at which the scales were set in the frame, conveyed the force they received directly to the scales. When the modified scales were in proper adjustment they presented a condition which was natural except for the slight give in the blocks.

Factor Measured.—The question of what was measured immediately arises. We have seen fit to call it force, drive, or pressure, although we

are aware of the fact that in the more limited sense it was not force, drive, or pressure. It was reasonable to assume, however, that whatever measure was indicated by the dial hand of the scales when a starter left the blocks was a measure of something which at least represented the force, drive, or pressure exerted by the sprinter. Since this appeared reasonable, it seeemed legitimate to use this measure for purposes of comparison.

Definition of Types of Starts Used.—In this experiment four starting positions were employed. The first procedure was to allow the sprinter to set a pair of ordinary starting blocks for his natural starting position.

Measurements were taken from these blocks and were used in setting the modified scales for one of the four starting positions. From this natural starting position three other positions were figured out by moving the blocks closer together or farther apart, using about a five-inch interval for each change. For example, if the blocks were placed for the natural starting position and the distance between was sixteen inches, the other three positions were represented by spacings of eleven, twenty-one, and twenty-six inches plus or minus one-half inch, depending on the size of the man. Variations from the five-inch interval, due to the size of the foot, were never more than plus or minus one inch.

If the spacing for the natural starting position was eleven inches, two positions were established which were farther apart. When the interval for the natural position was twenty inches, two experimental positions were established where the interval was less and one where it was greater.

The established spacings provided positions which approximated very closely the bunch, the normal, and the elongated starting positions as customarily described. One additional starting position was used, i.e., the natural start.

This variety of foot spacings provided a basis for studying the tendency of force distribution as influenced by the distance between the blocks. The conditions under which the starts were made were very similar to those experienced by a sprinter in regular practice. The starting was done by an experienced starter. The customary commands were employed.

In order to overcome some factors which might influence the start, the order of the positions investigated was rotated with the thirty subjects. In this way such elements as fatigue, warming up, and condition were distributed through the experiment and thus submerged so that they were not determining factors in the results.

The experiment was conducted indoors on an experimental track which is essentially the same as that used for indoor competition.

THE DATA

By means of the technique just described, data were collected from 30 trained track men. Each subject came to the laboratory once, making 10 starts from each of 4 positions, a total of 40 starts in all. A summary of

the mean pressure exerted by both feet in all starting positions is presented in Table I.† The data in this table show that the mean pressures exerted by the foot front in positions 1, 2, 3, and 4 were 195, 190, 190, and 196 pounds, respectively. It should be stated here that position 1 is the bunch start; position 2, the natural start; position 3, the medium start; position 4, the elongated start. The range for all positions was 6 pounds. For the foot back the mean pressures exerted were 151, 173, 196, and 208 pounds. The range for the foot back was 57 pounds. The total

TABLE I

A Comparison of the Mean Force Exerted by the Leg Front with the Leg Back in the Four Starting Positions Including a Summary of the Data from Thirty Subjects

Subject	Mean Pressure Exerted							
	Position 1		Position 2		Position 3		Position 4	
No.	Front	Back	Front	Back	Front	Back	Front	Back
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1	203.8	136.5	199.5	158.9	209.3	170.0	204.6	188.5
2	138.0	131.1	132.4	135.4	147.6	174.1	169.1	163.0
3	205.5	119.0	207.5	155.0	214.0	178.0	229.6	175.5
4	124.7	138.6	122.2	138.8	113.9	152.0	138.0	181.0
5	231.0	211.0	246.2	212.0	242.3	206.0	236.0	244.5
6	206.5	208.0	171.6	245.9	162.6	267.0	176.0	274.0
7	140.0	129.2	129.6	160.0	129.9	195.6	135.0	213.0
8	125.0	182.0	126.8	204.1	130.5	221.0	143.5	199.6
9	222.8	99.0	228.0	118.0	217.2	134.0	217.2	159.0
10	178.3	141.0	166.0	152.2	159.0	158.5	154.8	296.5
11	238.7	184.8	245.3	251.5	236.9	242.4	234.7	236.3
12	181.2	150.5	172.8	173.6	183.4	190.0	187.4	184.5
13	257.0	207.0	273.6	272.4	268.5	282.5	303.0	255.0
14	186.4	149.5	189.4	192.5	190.6	238.0	188.8	258.5
15	168.9	94.5	152.0	118.6	166.4	155.0	163.5	153.2
16	207.0	143.6	184.9	138.4	202.8	183.5	200.4	180.5
17	212.7	133.2	201.7	143.5	196.8	160.0	196.8	191.0
18	215.4	172.4	224.6	179.5	221.4	196.8	225.2	171.0
19	200.2	104.0	203.4	145.0	200.5	147.2	201.0	176.0
20	171.6	123.5	172.9	144.4	181.8	180.2	186.6	194.5
21	181.4	136.0	179.5	167.6	179.2	190.4	180.8	207.5
22	211.0	195.6	188.8	174.0	186.0	204.8	199.6	208.0
23	298.4	135.5	306.6	135.5	293.6	178.5	302.2	186.7
24	200.4	130.4	190.4	149.1	194.5	194.0	192.0	244.8
25	174.4	144.5	178.0	161.0	177.1	185.3	172.6	215.5
26	189.5	136.0	194.0	146.0	189.8	131.7	190.1	140.2
27	240.0	158.0	203.5	230.5	171.3	262.0	162.0	283.0
28	194.0	227.0	196.4	234.5	222.5	269.0	230.4	256.0
29	195.2	189.6	187.2	195.0	194.5	207.0	216.0	267.0
30	129.0	119.0	122.7	149.5	124.4	185.0	131.5	209.0
Mean	195.3	150.7	189.7	172.7	190.3	195.8	196.0	208.3
P.E.	±4.88	±4.26	±5.17	±5.13	±4.95	±4.77	±5.06	±4.53

† The raw data are omitted from this report but are on file in the library of the State University of Iowa. J. W. Kistler, A Study of the Distribution of the Force Exerted Upon the Blocks in Starting the Sprint from Various Starting Positions, M.A. Thesis, June, 1933.

mean pressures exerted by both legs for the four positions were 346, 363, 386, and 404 pounds, respectively.

It can be seen from Table I that, for the group as a whole in positions one and two, the greatest pressure was exerted by the leg front; in position three, the pressure exerted by the two legs was practically equal; while in position four, the greatest pressure was exerted by the leg back.

From an examination of the data collected from the individual cases, the data show for position one, twenty-six of the thirty cases exerted the greatest pressure with their leg front while four of them did the reverse. The data from the twenty-six cases showed that in 92 per cent of the starts the greatest pressure was exerted by the leg front. For all thirty cases, the data showed that in 80 per cent of the starts for position one, the greatest force was exerted by the leg front. In position two, eighteen of the thirty cases exerted the greatest driving force with the leg front while twelve of them drove hardest with their leg back. From this position 61 per cent of the starts made by the whole group showed that the greatest drive was with the leg front. In position three, fourteen subjects drove hardest with the leg front and sixteen with the leg back. The data showed that for this position in 47 per cent of the total starts made by the group, the drive was greatest with the leg front. In other words, the drive was practically equally distributed between the two legs. In the next position the situation was reversed. Only thirteen of the thirty subjects drove hardest with the leg front while seventeen drove hardest with the leg back. For this position, in 34 per cent of the total starts the drive was hardest with the leg front.

An examination of the data in Table I shows that for twenty-one of the group the drive was greatest from the leg front, in the natural starting positions, while for seven it was greatest for the leg back and for two the drive was equally distributed between the leg front and the leg back.

The raw data revealed that the natural position assumed by thirteen of the group gave an antero-posterior block spacing of ten to twelve inches. This distance was from fourteen to sixteen inches for fifteen subjects, and twenty inches for two subjects.

SUMMARY AND CONCLUSIONS

Data were collected from thirty trained sprinters by means of an apparatus designed for measuring the amount of drive exerted by the legs in the start of the sprint. The data thus collected showed the following:

1. In starting the sprint, the drive was executed by both legs regardless of the antero-posterior distance between the blocks.

2. The drive from the leg front was relatively constant regardless of the foot spacing.

3. As the antero-posterior distance between the blocks was in-

creased there was a tendency for the drive exerted by the leg back to increase.

4. In the neighborhood of an antero-posterior foot spacing of twenty inches the distribution of the drive between the two legs was about equal, and as this spacing interval was increased further, the drive from the leg back exceeded that of the leg front.

5. The total pressure exerted in the drive increased as the antero-posterior distance between the feet was increased.

6. Judging from this study, the majority of sprinters got the major part of their drive from the leg front in their natural starting position.

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An Experimental Study of Reaction Time of the Start in Running a Race*

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IT REQUIRES some time for one to react to an external stimulus. For instance, in starting a race some time elapses between the "gun" and "leaving the marks" by the runner. In addition to this, the timekeeper consumes some time in stopping the watch after the contestant breaks the tape. In short races these reaction times are important since they may consume as much as .5 seconds. In a 100-meter race .1 second means about 3 feet. Since a distance of a few inches many times determines the winner, .1 seconds at the start may determine who finishes first.

REVIEW OF LITERATURE

This type of experiment had not been conducted in Japan, up to the present time, as far as the writer knows. Scripture†[1] reported some experiments on this point but did not give detailed conclusions. However, he did report that the reaction time of runners specializing in short distances who are trained to start quickly was about one-third shorter than that of those who run long distances. Scripture also stated that the reaction time for the movement of the whole body was longer than for the movement of a single member. A picture of this same experiment appeared in a book by Schulte,[2] but he gave no results.

THE METHOD OF STARTING A RACE

As a rule, sprinters start from a crouching position from holes dug in the ground. The starting signals are (1) "on your mark," (2) "get set," and (3) "gun."

When the signal, "on your mark," is given, the runner takes his position in the holes. The position of the feet depends on the "footedness" of the contestant. If he is left footed, he puts his left foot in the front hole and, if he is right footed, he puts his right foot in the front hole. If

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* This is a translation and condensation of the original article as it appeared in the *Japan. J. Psychol.*, III (1928), 231–262, made by Hugh Chan in collaboration with W. W. Tuttle and George T. Bresnahan. From the Department of Physiology, State University of Iowa, Iowa City, Iowa.

† Numbers refer to bibliography at end of article.

the left foot is in the back hole, the left knee is touching the ground and the right knee is off the ground. The left cheek of the buttocks is usually directly over the left heel and both hands are placed lightly on the ground. At the signal, "get set," the knee is raised off the ground and the body is pushed slightly forward. The sole of the foot is placed firmly against the back of the hole and the head is raised so that the contestants can see about ten meters ahead of him. In this position both arms are approximately parallel to one another, and the weight of the body is on the arms and the leg in front while the leg behind is in a state of inactivity. At the "gun," both arms are put in motion, the right arm coming up in front and the left arm up in back. (The relative position of the arms is governed by the footedness of the contestant.) At the same time the competitor exerts as much force as possible against the back of the hole with the back foot, thus causing the beginning of the forward movement. Although there are three movements, they begin at the same time. The principle involved in this position is that when the hands are lifted from the ground the body falls forward.

OBJECT OF THE EXPERIMENT

The object of this experiment was to determine the time elapsing between the "gun" and the time the runner left the starting holes, under different conditions.

TECHNIQUE

In order to record the instant that the gun was shot the trigger was equipped with an electrical contact which started a chronoscope constructed by the writer. The hands of the subject rested on electrical contacts which stopped the chronoscope when the hands were lifted from the ground. The chronoscope was run by battery current, adjusted to 7.5 volts and 1.6 amperes. Before and after each experiment the accuracy of the chronoscope was checked by a sound hammer about 10 times for 100 to 250 intervals.

The most important techniques involved in the experiment were the shooting of the gun and the reading of the chronoscope. The writer did the shooting and a friend read the chronoscope. Twenty-two individuals served as subjects on thirty different occasions. The experimental racing track was arranged so as to duplicate actual racing track conditions. The chronoscope was inside and was connected by wires to the gun trigger and to the contacts on which the subject's hands rested. The gun firer stood in the position ordinarily assumed by an official starter of races, viz., six meters in front and to the right of the subject. In order to eliminate the element of fatigue each subject was given five minutes rest after each reading.

The problem was approached from three different angles as follows:

1. The study of the simple reaction time by measuring the time

elapsing between the sound of a hammer and the release of a key by the left index finger.

2. A study of starting reaction time as influenced by the length of time elapsing between the command, "get set," and the firing of the starting gun.

3. A study of the starting time of a subject as in (2) but when there was a competitor in an actual race.

In addition to the above problems the following factors were recognized but were not included in the experiment:

a. The effect of the fluctuations of attention on reaction time.

b. The effect of fatigue on reaction time.

THE DATA

Simple Reaction Time.—Ten athletes were used in this part of the experiment. Thirteen readings were taken for each subject using the sound hammer method, of which the first three were discarded. The average and the average differences were taken of the ten remaining readings. The data are shown in Table I, and graphically in Figure 1. In case some of the readings were radically different from the average, they were discarded. In this experiment the subject and chronoscope were separated as far as possible. Although an attempt was made to eliminate distracting sounds from the subject, it was not fully accomplished.

Starting Reaction Time.—The same ten subjects used in determining simple reaction time were given thirteen trials each from the starting holes and their starting reaction times were measured. As before the first three readings were discarded and an average and the average differences were calculated. The data are shown in Table I, and graphically in Figure 1.

TABLE I

A COMPARISON OF STARTING TIMES WITH SIMPLE REACTION TIMES

Subject	A. Simple Reaction Time Sound Hammer		B. Starting Reaction Time		Difference (B)− (A)	Ratio (B)/(A)
	Reaction Time δ	M.V.	Reaction Time δ	M.V.	δ	
A_1	133.3	± 8.50	153.0	±13.00	19.70	114.78
S	131.2	±10.76	173.2	± 7.44	42.00	132.01
Y	137.0	± 6.10	209.0	±13.60	72.00	152.55
H_1	129.6	± 6.50	182.0	± 9.20	52.40	140.43
U_1	145.5	±13.80	150.7	±13.62	5.20	103.57
T_1	129.8	±10.00	170.7	± 4.44	40.90	131.51
M_1	115.8	± 4.84	165.7	± 9.44	49.90	143.09
M_2	123.0	± 4.40	174.8	± 5.84	51.80	142.11
U_2	163.4	±13.10	206.6	±20.10	43.20	126.44
O	121.2	± 9.32	210.6	±14.88	89.40	173.76
Mean	132.98	± 8.74	179.63	±11.16	46.65	135.08

A Comparison of Simple Reaction Time and Starting Reaction Time.—The comparison is shown in Table I. Simple reaction time is designated A and starting reaction time B. The data revealed the fact that the slowest simple reaction time was made by subject U_2 (163.4 σ) and the fastest by subject M_1 (115.8 σ). The average simple reaction time was 132.98 σ.

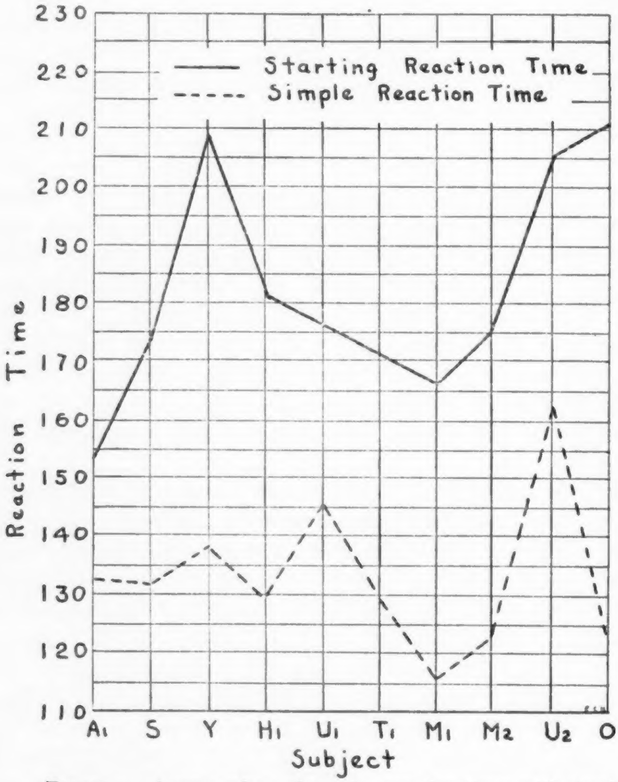

FIGURE 1.—A comparison of starting reaction times with simple reaction times.

A comparison of the simple reaction time as found in this experiment (132.98 σ) with that reported by Titchener[3] (140–190 σ) showed that the former was a little faster, but, when compared with his motor time (120 σ), it was slower. The findings of Wundt[4] (127 σ) and those of this experiment are about the same.

In the starting reaction time experiment, subject O was slowest (210.6 σ) and subject A_1 was fastest (153.0 σ). The average of the group was 179.63 σ. This is about the same as Titchener's[3] simple reaction time for sound. When compared with the simple reaction time found in this

experiment it was 46.65 σ slower. The smallest difference (5.20 σ) occurred in case of subject U_1 and the greatest (89.40 σ) for subject O. The other eight were distributed between these extremes. However, in every case the starting reaction time was slower than the simple reaction time.

A further comparison of the simple reaction time and the starting reaction time is made in Figure 1. The simple reaction time is plotted as a dotted line and the starting time as a solid line. It is seen that the dotted line is always below the solid line and that they never cross each other. They are closest together for subject U_1 and farthest apart for subject O. The average ratio of starting reaction time to the simple reaction time was 135.08. The smallest ratio (103.57) occurred in case of subject U_1 and the largest (173.76) for subject O. The smallest per cent difference between simple reaction time and starting reaction time was 3.57 (subject U_1) and the largest was 73.76 (subject O). The mean per cent difference was 35.08.

The data showed that the starting reaction time was definitely longer than the simple reaction time. This was due to the fact that in the former the whole body must be moved while in the latter just the finger must be raised.

Furthermore, since the simple reaction time depended on a hammer for its stimulus and the starting reaction time upon a gunshot, there must be some variation in the two due to the strength of the stimuli. It has been shown by Berger[5] for light and by Martius[6] for sound that, within limits, reaction time becomes shorter as the strength of the stimulus becomes stronger. Just how intense the sound of the gun really was is a problem for further scientific study. Although I recognized this phase of the problem I could not give it further consideration at the time. But the difference in the reaction times as shown above seems to be mostly due to the difference in the methods employed.

Several years ago Shimizu[7] studied the reaction time of four subjects and found it to be 124.13 σ. The mean difference was 15.39 σ. The mean simple reaction time found in this experiment (132.98 σ) was 8.85 σ greater than that found by Shimizu, but the mean difference (8.74 σ) was less. Shimizu also compared the reaction time of the Japanese with that of foreigners and found that the reaction time of the Japanese was shorter than that of the foreigners. My experiment showed the same thing to be true.

The results of this investigation showed that for 10 subjects there was an individual variation in simple reaction time from 115.8 σ to 145.5 σ. According to Wundt[4] these variations are due to (a) direction of attention, (b) habit of reaction, and (c) the type of reaction. Direction of the attention means that on which one concentrates more, the stimulus or the reaction, between the stimulus and the response. The habit of reaction refers to the individual method employed by subjects. For

example, one person may put his finger lightly on a response key while another may press it firmly. Still another may exert great pressure during the period of expectation, but gradually decrease it so that when the stimulus is received there may not be any pressure on the finger at all. Still, other persons may do exactly opposite to the last one described.

Another point to be considered is that some persons are motor and some sensory responders. Titchener[8] has shown that some sensory reactors cannot adapt themselves to the motor type of response. In some cases when one attempts to teach the motor type of response to one who naturally belongs to the sensory type the subject fails to make the shift and the longer he practices the more mistakes he makes and the longer his reaction time becomes.

The Effect of the Time Elapsing Between the Signal "Get Set" and the "Gun".—At the present time, according to the Japanese rules governing track and field meets, there must be at least two seconds time elapsing between the signal, "get set," and the shooting of the gun. There has been a lot of discussion concerning this interval, whether it is suitable for a runner. When the command, "get set," is given, all the runners have a tendency to push their bodies forward. A two-second interval of waiting becomes quite distressing. According to my experiment, there is no reason for waiting two seconds. Therefore, I have a special interest in this problem.

Between the "get set" signal and the gunshot in this part of the experiment 3 different intervals of time were used, viz., 1 second, 1.5 seconds, and 2 seconds. The procedure for carrying out the experiment was as follows: I had 36 index cards. On 12 of them I put 1 second; on 12 more, 1.5 seconds; and on an additional set of 12, 2 seconds. Before each experiment a card was withdrawn at random. By this method, the time interval to be used was determined. Each subject did 36 starts. I have had experience as an official starter, therefore I did the starting so that it would be just as real as possible. The time intervals were determined by a metronome. Beforehand I practiced several times in order to adjust myself to the use of the metronome.

The subjects were not told the exact time interval that was to be used; however, they understood that it would be from one second to two seconds. Each subject was given five minutes rest between trials and after the tenth, an additional five minutes were allowed, if necessary. After the experiment each subject was asked to write down what he thought of it.

Data were collected from 10 subjects. They are shown in Table II. It is seen that the mean starting reaction time for the 1-second interval was 198.92 σ. The range was 158.1 σ (subject T_1) to 231.4 σ (subject A_2). The mean variation was 19.75 σ. The mean starting reaction time for the 1.5-second interval was 170.75 σ. The range was 148.0 σ (subject T_1) to 210.5 σ (subject A_2), and the mean variation was 11.35 σ.

For the 2-second interval the mean starting reaction time was 201.87 σ. The range was 160.0 σ (subject T_1) to 246.8 σ (subject A_2), and the mean variation was 18.71 σ.

Of the three intervals studied, 1.5 seconds gave the shortest starting reaction time. For all 10 subjects there were no exceptions. The next shortest starting reaction time occurred at the 1-second interval and the slowest when the 2-second interval was used.

TABLE II

A Comparison of the Starting Reaction Times for Various Intervals of Time Between the "Get Set" Signal and the "Gun"

Subject	A. Time between "get set" and "gun" 1 second			B. Time between "get set" and "gun" 1.5 seconds		C. Time between "get set" and "gun" 2 seconds		
	Reaction Time δ	M.V.	Ratio (A)/(B)	Reaction Time δ	M.V.	Reaction Time δ	M.V.	Ratio (C)/(B)
H_1	208.4	±10.16	106.76	195.2	± 4.60	223.0	±12.40	114.24
I	204.3	±19.38	107.30	190.4	±14.20	207.4	±15.00	108.92
A_2	231.4	±20.86	109.93	210.5	±22.40	246.8	±28.08	117.24
M_3	184.6	±22.16	104.35	176.9	±13.04	191.0	±24.60	107.97
T_2	191.9	±20.08	105.15	182.5	±15.90	201.2	±16.16	110.25
M_4	194.4	±29.24	113.62	171.1	±11.88	181.9	±13.82	106.31
T_3	215.3	±29.60	115.19	186.9	± 8.12	223.1	±22.90	119.37
U_2	210.6	±27.12	132.37	159.1	± 7.02	188.8	±18.88	118.67
T_1	158.1	±13.44	106.85	148.0	± 9.20	160.0	±11.80	108.11
M_5	190.2	± 5.46	101.78	186.9	± 7.12	195.5	±13.50	104.60
Mean	198.92	±19.75	116.50	170.75	±11.35	201.9	±18.71	118.22

The results of this experiment are shown graphically in Figure 2. The broken line represents the 2-second interval, the light continuous line the 1-second, and the heavy line the 1.5-second interval. This figure shows that the lines representing the data are more or less parallel, the 1.5-second line being below the others and never crossing them. In two instances, subjects T_1 and T_2, the 1-second and 2-second lines cross each other. On the basis of per cent the relative difference between the 1.5-second and the 1-second intervals, and the 1.5-second and the 2-second intervals, was 1.72. The smallest difference between the 1-second and the 1.5-second intervals was 4.35 per cent (subject M_3) and the greatest, 32.37 per cent (subject U_2). The mean per cent difference was 16.5 in favor of the 1.5-second interval. When the 1.5-second interval was compared with the 2-second interval on the per cent basis, the smallest per cent was 4.6 (subject M_5) and the largest, 19.3 (subject T_3). The mean average was 18.22 per cent, in favor of the 1.5-second interval. Comparing the 1-second and 2-second intervals on a per cent basis, the latter was 1.72 greater than the former. Out of the group of 10 subjects, 9 of them showed very little differences in the 1-second and

the 1.5-second intervals. When the mean variation was considered we found that it was least (11.35) for the 1.5-second interval. It was about the same for 1 second (19.75) and 2 seconds (18.71). From this point of view 1.5 seconds seems to be the most stable interval for the start.

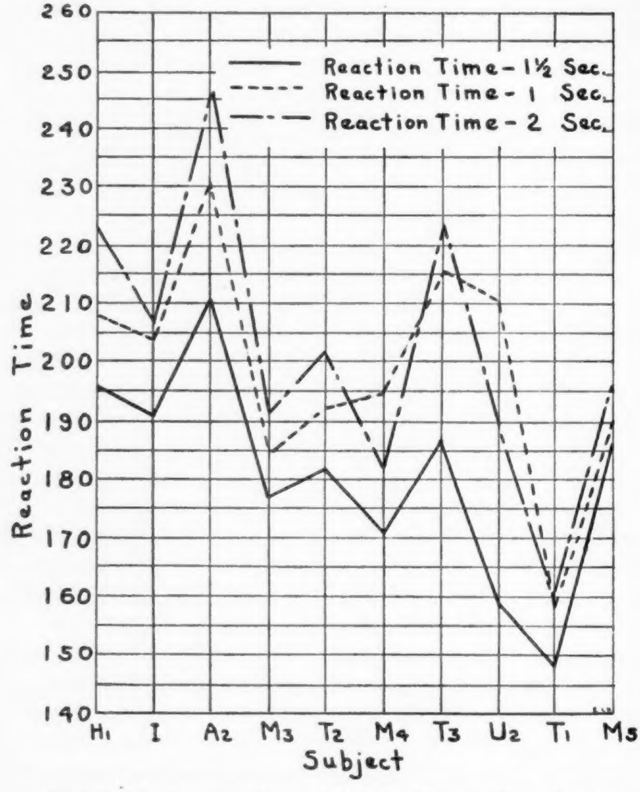

FIGURE 2.—A comparison of the starting reaction times for various intervals of time between the "get set" signal and the "gun."

The subjects reported after the experiment that when only 1 second was allowed between the "get set" signal and the "gun" their attention was not organized and they were still getting poised when the gun was shot. For the 2-second interval they reported that their attention had begun to fluctuate. At 1.5 seconds every subject reported that his mental poise and physical set were ready.

Dwelschauvers,[8] in his sound experiment using intervals of 1.5, 3, and 6 seconds between the preparatory command and the stimulus, found that 1.5 seconds was the optimum interval and I found the same thing to be true in my experiment. Of course, Dwelschauver's use of intervals of 3

and 6 seconds was out of the question in a race. My result was verified by the report of the subjects. For this reason I think that my results are trustworthy. Naturally, when the attention is fixed the reaction time is shorter. Attention is not fixed over a period of time but fluctuates continuously. As time goes on the attention increases, eventually reaching its highest point from which it usually decreases as time progresses. For this reason when the interval between the "get set" signal and the gunshot was changed the starting reaction time changed also.

According to the results of this experiment, the 1.5-second interval was found to be the optimum time between the command, "get set," and the "gun." In 1 second the attention was not at its height; in 2 seconds the attention was fluctuating. In both cases the starting reaction time was prolonged.

The Influence of Competition on Starting Reaction Time.—This experiment was carried out in order to determine the effect of competition on starting reaction time. As in the previous experiments ten subjects were used.

The procedure in this part of the experiment was to record the starting reaction time of a subject and, after a little rest, repeat the experiment with a competitor running beside the subject. The subject was encouraged to win the race and in the process of the experiment the competitor seemed to live up to the encouragement as well. Some of the subjects became so interested in the results of the race that they put forth a maximum effort to win. On the basis of the preceding experiment I used 1.5 seconds as the interval between the command, "get set," and the "gun."

The data collected in this experiment are shown in Table III. For convenience the individual starting reaction time column is marked *A*, and the one with a competitor, *B*. The data indicated that the group

TABLE III

A Comparison of Individual Starting Reaction Time with Competitive Starting Reaction Time

Subject	A. Running alone		B. Running with competition		Difference (B)-(A)	Ratio (B)/(A)
	Reaction Time σ	M.V.	Reaction Time σ	M.V.		
H_2	250.0	±14.0	205.4	±17.52	—44.6	82.16
K	254.5	±12.7	238.0	± 7.40	—16.5	93.51
U_1	150.7	±13.62	180.8	±14.04	+30.1	119.97
T_1	170.7	± 4.44	174.9	± 9.94	+ 4.2	102.46
M_1	165.7	± 9.44	174.0	± 5.60	+ 8.3	105.09
M_2	174.8	± 5.84	178.3	± 7.36	+ 3.5	102.00
S	173.2	± 7.44	169.9	±10.40	— 3.3	98.09
Y	209.0	±13.60	171.4	± 8.20	—37.6	82.00
A_1	153.0	±13.00	159.5	±12.50	+ 6.5	104.25
T_4	151.3	± 4.50	145.4	±12.32	— 5.9	96.10
Mean	185.29	± 9.86	179.76	±10.73	— 5.53	97.01

was composed of both sensory and motor reactors. The mean average variation for the two experiments was practically the same (A, 9.86 σ; B, 10.73 σ). The data showed that for 5 subjects the starting reaction time without a competitor was shorter than when the race was run with a competitor. For the 5 remaining cases the reverse was true.

The data are shown graphically in Figure 3. The solid line represents the individual race and the broken line the one with a competitor. In

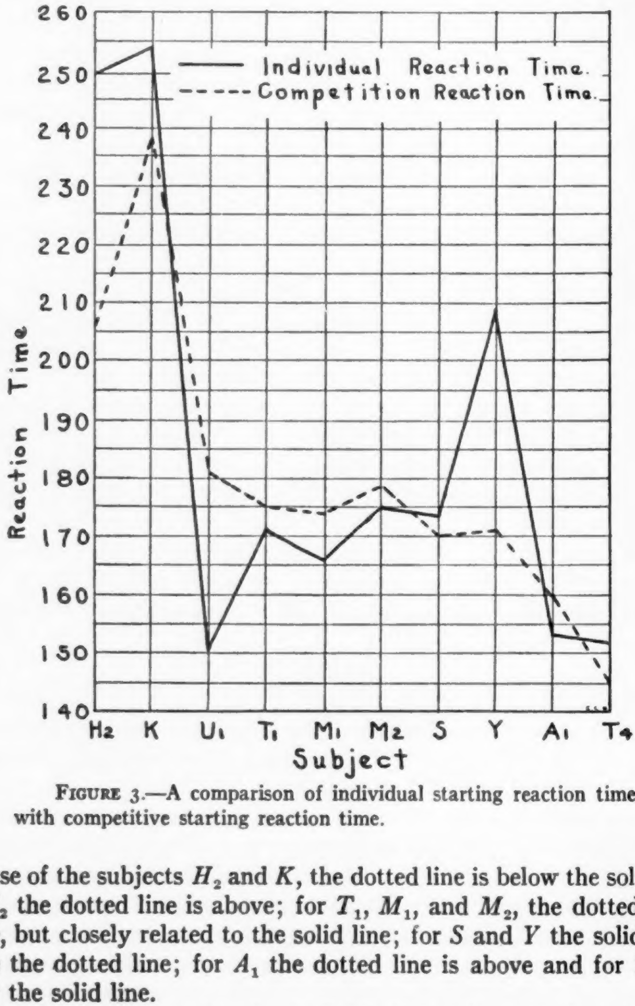

FIGURE 3.—A comparison of individual starting reaction time with competitive starting reaction time.

the case of the subjects H_2 and K, the dotted line is below the solid line; for U_2 the dotted line is above; for T_1, M_1, and M_2, the dotted line is above, but closely related to the solid line; for S and Y the solid line is above the dotted line; for A_1 the dotted line is above and for T_4 it is below the solid line.

The mean average for the individual starting reaction time was 185.29 σ. The mean difference was 5.53 σ in favor of the competitive race. This difference was too small to have any significance.

Of the five subjects who were slower in competition than in individual response, subject U_1 gave the greatest difference which was 19.90 per cent. Out of the group of five who were faster in competition than alone, subject H_2 gave the greatest difference which was 17.84 per cent. For the group, the competitive starting reaction time was 2.99 per cent faster than the individual starting reaction time. The subjects reported that in a competitive race there existed the selfish motive of winning, and that they paid greater attention and put more energy into it.

DISCUSSION

It has been proved that an interval of 1.5 seconds between the command, "get set," and "gun" was the best suited to runners and therefore this time interval is important. It is unnecessary to discuss the importance of alert hearing and short reaction time on the part of a runner. In one case in the first part of this experiment the simple reaction time varied from 210.6 σ to 150.7 σ, the difference being 59.9 σ. If a 100-meter race requires 10 seconds, the sprinter travels about 10 meters in 1 second. In .1 seconds he goes 1 meter. In the example just cited the slowest reactor had a handicap of one-half meter. One cannot take this lightly because it may be the decisive factor in a 100-meter race. Where is the attention of the runner focused between the command, "get set," and the "gun?" This problem is more a psychological one than one of reaction time. The changes in reaction time due to changes in the mental attitude are more numerous than those caused by outside stimuli. The most outstanding cause of changes in mental attitude is attention. When we receive an outside stimulus, the first thing that we must consider is the condition of attention. Cattell [10] discovered in his research that when the stimulus was anticipated the reaction time was shorter. Therefore, it is very important that in the start one must be anticipating the "gun" and be at the height of attention. A characteristic of attention is fluctuation. At first attention tends to become focused, and then over a long period, it fluctuates. Therefore, in starting a race the attention must be at its height so that when the gun is heard attention is at its peak. The official starter must time the gun so that it coincides with the peak of the runner's attention. This is an important problem and cannot be disregarded. Griffith[9] said the same thing.

The attitude of mind may cause either a muscular reaction or a sensory reaction. Muscular reaction refers to the physical set and is started reflexly by the sound of the gun. The sensory reaction occurs when the attention is focused on the sound of the gun. Titchener[8] has investigated these types of responses and found that muscular reaction time was 120 σ; and sensory, 230 σ. The difference between sensory and muscular response was 110 σ, which was more than .1 second. Of course, Titchener's experiment was not an experiment in starting a race

but was conducted indoors by means of a sound hammer. However, one could expect similar results in an actual starting experiment.

In my experiment, subjects whose reaction time was more than 200 σ reported that their attention was given to the gunshot. Those subjects whose starting reaction times fell between 100 and 150 σ reported that they responded reflexly. It was evident that during the interval between the "get set" signal and the gun, a runner must focus his attention and have the desire to start as soon as he hears the gun.

I have my doubts concerning the statements which Noguchi[11] makes when he says, "The problem of hearing the 'gun' as soon as possible is the problem of greatest importance. For this reason, one must pay attention to the location of the starter and concentrate on the anticipation of the sound of the 'gun.' I think this is profitable only to the beginner. Experienced men who have started hundreds of times develop their own technique. The very minute an experienced runner hears the command, 'get set,' he lightly inhales and then pays no further attention to either his surroundings or the sound of the gun. He is completely lost in the race and his mind is blank." I think there is the necessity of having the desire to start at the moment the gun is fired. What Noguchi said concerning the concentration on the gun must be regarded as sensory response. Sensory response is much slower than motor reaction. Therefore, I still think that the attention must become reflex, and one must have the desire of starting at the sound of the gun.†

CONCLUSIONS

The important points brought out by this investigation are as follows:

1. In the simple reaction time experiment where the stimulus was given by means of a sound hammer and the response by the left index finger the mean was 132.98 σ. In the starting reaction time experiment, the mean was 179.63 σ. The mean difference showed the simple reaction time to be 46.65 σ faster than the starting reaction time. The simple reaction involved only the movement of a finger while the starting reaction included the whole body.

2. The optimum time interval between the signal, "get set," and the gun was found to be 1.5 seconds. Furthermore, the mean variation showed that the responses were more consistent when this time interval of 1.5 seconds was used. The validity of these findings was substantiated by the report of the subjects. They reported that an interval of 1 second was too short for them to get their attention focused and their poise established, and that 2 seconds was too long since a fluctuation of attention occurred and there was a tendency to become sensory.

3. The results obtained concerning the psychological effect of com-

† I published an article on this point in the *Kumamoto Education*, CXC, 14–18. Last year I was pleased to find the same theory recognized in America by Griffith.

petition on starting reaction time were not clear. One-half of the subjects were faster without competition and the other half reacted more quickly with it.

4. The time elapsing between the command, "get set," and the "gun" is the most important phase of the start of a race. The runner must, as far as possible, anticipate the gunshot and have his attention at a maximum when the shot occurs and at the same time be set to respond reflexly. At the sound of the gun the runner must concentrate on winning the race. I have my doubts concerning the theory of Noguchi as previously stated. Griffith agrees with me.

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The Measurement of General Motor Capacity and General Motor Ability

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I. GENERAL MOTOR CAPACITY

THE INVENTION of valid and adequate tests of general intelligence marked the beginning of a greater increase in the scientific control of research in classroom education and in more satisfactory methods of classification for school work. In addition, these tests offered to thoughtful teachers a tool, the results of which gave a rapid and relatively accurate measurement of one of the child's most important capacities—a measure that could be obtained in a day and which has been proved to be far more valid than teachers' estimates made after a year's observation. The fact that the naive and uninformed have misused this excellent tool by applications for which it was never intended and by interpretations that were weird in no way detracts from the usefulness of the discovery.

There is a need in physical education for an analagous test equally valid and useful in its own peculiar field. This study attempts to present such a test, which, while it admittedly has shortcomings and imperfect subelements, may be utilized until a better test has been developed to take its place.

As the ordinary intelligence tests are really tests of *general* abstract intellectual capacity, so this is a test of *general* innate motor capacity. In this term the word, "capacity," indicates that the test attempts to measure not so much developed ability as innate potentialities—the limit to which the individual may be developed. The word, "motor," is used primarily in the sense of the neuromuscular and only secondarily in the sense of the psycho-motor. In other words there is no attempt to measure what might be called "athletic smartness" but rather to measure capacity to learn new skills, as well as to measure the more distinctly large-muscle capacities involved in potential strength and speed of muscular contraction. The word, "general," indicates that these motor capacities measured are the basic fundamental ones that apply to almost all motor performance. There is no attempt to measure *specific* skills and abilities.

In devising a test such as this the student is confronted with the

dilemma faced by the formulaters of intelligence tests, namely, that in an endeavor to measure capacities or potentialities certain skills and abilities—as they are at the time—must be utilized. The intelligence tests avoid this difficulty largely by utilizing items of information which may be assumed to be either the common property of almost all those who take the tests or to which the tested person may be assumed to have been exposed to a degree that, if the individual is sufficiently intelligent, should have been enough to insure his learning them. Thus, for tests devised for use in the senior high school, items are used which will have been presented to everyone in the grades. The test, of course, becomes invalid for those who have not had a grade school education or its equivalent. In the devising of this test of general motor capacity the same difficulty has had to be faced; and since the physical educator is less warranted than is the mental educator in assuming that any standardized skills have been learned in preceding grades, because of the chaotic lack of standardized curricula throughout our country, the elements chosen should be: (1) of themselves innately valid—such as elements of age, height, etc.; (2) such as to permit of a standard degree of practice being given previous to the test in order that all may be familiarized with the skill or form; or (3) only items that have been unpracticed by all so that the present opportunities for learning will be equal for each of the tested pupils.

This battery of tests endeavors to use such relatively simple test elements, practically all of which have been validated either by previous researches or by researches preliminary to this one. The actual test elements selected will be given below.

THE PROBLEM OF A CRITERION

In order that it may be adequately validated, every test developed by methods of scientific research must be measured against a criterion of the ability or capacity to be measured. Such criteria are often based upon one or more of the following principles:

1. The standards for the test should increase uniformly with each advancing year of age up to the point where further age increase cannot be expected.

2. A decided and significant difference should exist between the test scores made by two groups of known ability; one whose potentialities or abilities are excellent, and the other whose abilities are poor.

3. Teachers' judgments or ratings of the ability in question, or—what is almost the same thing—grades given in this subject, should correlate highly with the test results.

4. Correlation with batteries of objective achievement tests should be high.

5. Correlation with a battery of other tests purporting to test the same trait or ability should be very high. For example, one intelligence

test may be validated by correlating it against a battery of half a dozen other intelligence tests, all known to be highly valid.

In the experience of mental testers, teachers' judgments are prone to disagree conspicuously with the facts. The average correlation between teachers' judgments of intelligence and the best intelligence tests is around .45. In fact certain studies have been made which indicate that such ratings of intelligence correlate more highly with the docility, affability, and general appearance of the student than they do with the results of his objective examinations. Correlations with batteries of achievement tests are much more satisfactory, approximating .66.

Since there are no other tests purporting to measure general motor capacity in the sense defined above, we are not able to utilize the device of correlating this test against batteries of such tests of its own kind. We therefore decided to attempt to validate this test by correlating it against a battery of motor tests and to check this by correlating it as well against teachers' judgments.

The criterion as developed was arbitrarily made up as follows:

For Boys.—(1) the Classification Index [20 (age in years) + 6 (height in inches) + (weight in pounds); age not to exceed 17];* (2) pull-up strength, scored according to the author's formula;†[11] (3) 60-yard dash; (4) standing broad jump; (5) running high jump; (6) 8-pound shot put; (7) Sargent jump;[7] (8) what might be called a "pull-up physical fitness index"; this was the actual pull-up strength divided by the norm for pull-up strength; (9) Burpee test;[12] (10) Brace test of general motor educability;[6] (11) intelligence quotient as measured by the Otis self-administering test. These tests were "T" scored and the sum of the total taken as the criterion.

For Girls.—(1) the number of pull-ups, which pull-ups were done according to Rogers' technique;[3] (2) pull-up strength; the formula used for pull-up strength was one developed as a preliminary to this study and was as follows: [.67(weight) + 1.2(number of pull-ups) + 52]; (3) 60-yard dash; (4) standing broad jump; (5) throwing indoor baseball for distance; (6) Sargent jump; (7) pull-up physical-fitness index; (8) Burpee test; (9) Brace test; (10) intelligence

* A previous study (1 in bibliography) indicated that a certain combination of chronological age, height, and weight was of considerable value in predicting motor ability for boys; but another published study (2 in bibliography) indicated quite low correlations with these same variables and motor ability for girls; therefore, a preliminary study of the relationship of age, height, and weight to motor performance in girls was first conducted. This study will be published in detail later. Suffice it to say for the purpose of this paper that it was found that even with girls who were interested, who were judged by the teachers to be athletic, and apparently tried their best, the correlations between height and weight and athletic ability were practically zero. The correlation with chronological age was about .3 up to 11½ years of age, beyond which it became zero. Further experimentation indicated that so far as using these three variables (age, height, and weight) in a criterion of motor capacity for girls was concerned, they added nothing significant and we have eliminated them from further consideration.

† Numbers refer to bibliography at end of article.

quotient. These events were scored as indicated above for the boys' events. The total points were taken as the criterion.

In addition to the events enumerated above estimates were made of posture by the usual *A*, *B*, *C*, and *D* charts;[4] the Burpee test was given also for 30 seconds, and the ratio between the 30-second test and the 10-second test, which ratio it was hoped would be some measure of endurance, was computed. These two items, together with the intelligence quotient, added nothing significant and were discarded as not being useful in this kind of measurement of motor capacity.

It will be noted that each of the test elements later adopted is included in the criterion. Hence, there will be a slightly spuriously high correlation with the battery. Since there are eleven events for boys and ten events for girls this is not an important or serious matter when correlating the individual test elements with the total; it becomes more so as the whole battery is correlated with the criterion. The total correlations, therefore, should be read with this slightly spuriously high correlation in mind. On the other hand, as will be seen below, the intelligence quotient in every case had statistically insignificant correlations with each of the test elements, and this has probably lowered the resulting zero order correlations with the criterion as much as the inclusion of the individual test event itself increased it.

ANALYSIS OF THE RESULTS

The zero order correlations for boys and girls* are given in Tables I and II, in which the column labelled as zero is the criterion variable.

The reliabilities of the tests which were later selected for use are given in Table III. These reliabilities were computed on boys only. It should be noted that the groups for which the reliabilities were computed are in some cases not the ones upon which the tests were taken. Where the reliabilities were found to be sufficiently high in previous studies it was not thought necessary to recompute them. In interpreting these reliabilities the range should be noted.

Perusal of Tables I and II would quickly indicate that posture and intelligence quotient are of little value so far as this test is concerned. This leaves a total of six test elements (track and field events being combined into one total score) from which to choose. In these tables "total points" may be taken to mean the sum of four track and field events (boys), or three track and field events (girls), when scored on the author's scoring tables.[1] Preliminary study seemed to indicate that for girls the number of pull-ups was a better criterion of variable motor *ability* than was computed pull-up strength.

* The subjects used for the validation of the test consisted of 75 boys and 66 girls from the senior high school of Iowa City, Iowa. These tests were given by the author in collaboration with the two teachers of physical education in this school, Miss Helen Hayes and Dr. George Wells. The subjects used for the formulation of the standards comprised 422 boys and 333 girls from the Des Moines public schools.

TABLE I

Table of Intercorrelations of Tests Used

Boys

	0 Computed motor ability index	1 Total points	2 Pull-up strength	3 Classification index	4 Sargent jump	5 Brace test	6 Burpee test	7 Posture
0 Computed motor ability index .								
1 Total points	.8478							
2 Pull-up strength.	.7784	.6693						
3 Classification index	.6904	.4961	.8645					
4 Sargent jump ..	.7474	.6408	.4069	.3087				
5 Brace test	.5947	.5660	.2592	.1974	.5728			
6 Burpee test	.2728	.0878		.0117	.1820	.1090		
7 Posture	.0728	−.0299	.0256	.2942	−.1413	−.0544		
8 Intelligence quotient	−.0386	−.0893	−.1479		−.1547	−.0630		−.1738

TABLE II

Table of Intercorrelations of Tests Used

Girls

	0 Computed motor ability index	1 Total points	2 Number of pull-ups	3 Age	4 Sargent jump	5 Brace test	6 Burpee test	7 Posture
0 Computed motor ability index .								
1 Total points	.7657							
2 Number of pull-ups	.7939	.4361						
3 Age	.3046							
4 Sargent jump ..	.6609	.5691	.3690					
5 Brace test	.7399	.5106	.4853		.4898			
6 Burpee test	.6313	.4843	.3642		.2538	.5078		
7 Posture	−.1669	−.0538			.0770	−.3229	−.2121	
8 Intelligence quotient	−.1250	−.0612	−.0736		−.2077	−.0628		−.2058

ELEMENTS RETAINED IN THE TEST

In formulating a test of general motor capacity it was thought advisable to eliminate, as much as possible, events in which prolonged training and experience would have a large effect upon competence of performance. This would be true of such an event as the pull-up, and of track and field events. A study of all of these events by Finlay[5] indicated that over a prolonged and intensive training period performance in the track and field and pull-up events improved very rapidly, while there was practically no improvement in the Sargent jump, once the form of the jump had been learned. Of course the Classification Index would change with growth. Another study indicated some but not a great improvement in the Burpee test after it had been practiced. As is well

TABLE III
RELIABILITIES
(Computed on boys only)

Sargent Jump (grades 4 to 12)	.98
Brace Test (two halves, stepped up) (grades 4 to 12)	.83
Burpee Test (adults)	.72
Classification Index	.99
Total Points (Range, 4th to 12th grades)	.99 (after practice)
Pull-up Strength (adults)	.91
Whole Test (adults)	.90

known, the Brace test is dependent for its validity upon its not being practiced at any time.[6] Therefore, it was decided to retain the Classification Index (boys only), the Sargent jump, the Brace test, and the Burpee test given for ten seconds, as the test elements in a test battery for General Motor Capacity, and to combine the pull-up strength (boys) or number of pull-ups (girls) with the track and field scores into a test of General Motor Ability. This latter test will be discussed later.

As will be noted, this General Motor Capacity test battery is made up of various discrete elements each of which is designed to test a certain quite definite and specific capacity; these specific capacities added together make up the mosaic of the total general capacity.

The Classification Index is a measurement primarily of size and maturity. As Rogers[3] has pointed out, age and weight correlate very highly with strength. This is particularly true in those who have normally developed their strength. In other words, age and weight correlate very highly with *potential* strength. As the author has shown elsewhere,[1] age, height, and weight correlate excellently with general athletic ability, in which height assumes a more and more important part as the individual matures. Other evidence to be cited below confirms the place of the Classification Index in this battery.

The Sargent Jump is primarily a measurement of power, which is in turn composed of the elements of strength and velocity. In this case

the velocity is probably a function of the potential contraction speed of the muscles. This compound element of power is the fundamental one in all athletic and other motor performances involving speed.

The Burpee Test[12] has been much less well validated than have any of the other tests. Its inclusion in this battery was due to the experience of its originator in using one variation of this test as a device for estimating the motor ability of adults. As shown in Tables I and II, the correlations with the criterion are not high. The correlations with other elements of the test, however, are quite low, so that it apparently measures something not very well cared for by the other test elements. This is borne out by the "factor analysis" discussed below. The inclusion of the Burpee test is justified in addition by the fact that it raises the multiple correlation significantly. This test is designed to measure agility and a rather crude type of large-muscle coordination.

The Brace Test demands a slightly more extended discussion. When Brace[6] published this test in its original form it was hoped that it would be a measure of general motor capacity. The wide gap between the correlation of the Brace test with our criterion and the multiple correlation of the whole battery with our criterion would indicate that as a measure of general motor capacity it lacks something quite essential. However, it does give a relatively high correlation with every type of motor ability with which it is used. It is quite probable that the deficiencies are primarily those of size, strength, and speed, for the strength demanded is of a relatively low order. It would seem to the author that this test is primarily a test of motor educability which is probably closely related to the ability to develop high skill quickly (this statement is based upon the fact that highly skilled athletes in almost every sport score well in the Brace test). The original study for which the correlations are given utilized the Brace test in its original form. Since then the author has revised this test, adding new elements, omitting others, and changing the administration and the scoring. This revision has resulted in approximately doubling the validity of the test—estimating the validity not by the size of the correlation coefficient but by its predictive value as given by the coefficient of alienation.

These four tests, then, enable this General Motor Capacity test to be used not only as a total score but also as a "profile." That is, one may analyze the performance of each individual by the elements of the test as well as by the total score. Thus, a potential athlete who scored high in everything but the Brace test would probably develop more slowly into an excellent athlete, because although he possessed the purely motor capacities necessary he would develop form and skill more slowly. On the other hand, the individual with a moderately high Classification Index who scored high in the Brace and Burpee tests, but low in the Sargent jump, would be apt to develop early and to seem like a good prospect because of his skills; yet he would probably lack that speed and motor

"punch" which is one of the essential qualities of the outstanding athlete. Many athletic prospects who disappoint the coach are of this type.

BEST COMBINATION OF TEST ELEMENTS

The next step in the study was to devise the best weighting for each of the test elements. This was done by combining the correlations of each test with each other test and with the criterion in the form of an algebraic equation (multiple regression) which is of such a nature that when each test is weighted in this manner the correlation of the test score with the criterion is greater than it would be with any other combination of weightings. The results of this equation are given in Table IV. A similar computation was made for the General Motor Ability test and the results are also included in Table IV.‡

TABLE IV¶

FORMULAE FOR COMPUTING GENERAL MOTOR CAPACITY SCORES

The general motor *capacity* scores for the events of this test are computed by the following formulae:

1. *Elementary school boys*
   .181(Classification Index) + .7962(Sargent Jump in centimeters) + .5095 (Brace Test "T" score) + 2.187(Burpee Test) — 62
2. *Junior and senior high school boys*
   .3287(Classification Index) + 1.446(Sargent Jump in centimeters) + .9258 (Brace Test) + 3.973(Burpee Test) — 202
3. *Elementary school girls*
   3.576(Sargent Jump in centimeters) + 2.20(Brace "T" score) + 19.12(Burpee Test) + 119
4. *Junior and senior high school girls*
   3.576(Sargent Jump in centimeters) + 2.20(Brace "T" score) + 19.12(Burpee Test) + 119

FORMULAE FOR COMPUTING GENERAL MOTOR ABILITY SCORES

The general motor *ability* scores are computed by the following formulae:

5. *All boys*
   .10022(track and field points) + .3928(pull-up strength)
6. *All girls*
   .420(track and field points) + 9.6(number of pull-ups)

These combinations of events, as weighted, were then correlated against the criterion. The results are seen in Table V. In this table are included correlations from a subsequent study for the establishment of standards.§

‡ The actual weightings found originally were slightly different from these given here, but were strictly proportional. These weightings equate the General Motor Capacity formula to the General Motor Ability formula in such a manner as to avoid the necessity of an intermediate step.

¶ Tables for facilitating all computations are published privately by the author and will be furnished at cost. See bibliographical reference number 10.

§ The data for this study were obtained in the Des Moines high schools through the courtesy of Louis E. Hutto, Supervisor of Physical Education, and a large corps of teachers.

In Table V it will be seen that the correlations with the criterion scores are exceedingly high. The correlations with teachers' ratings of motor ability are somewhat lower. However, when it is remembered that the correlations of the best intelligence tests with teachers' ratings average .45, it will be seen that our correlations would indicate that the test of General Motor Capacity, as presented, is a more valid measure of general motor capacity than the intelligence quotient is of general intellectual capacity.

TABLE V

MISCELLANEOUS CORRELATIONS

Let c = computed motor index (criterion)
r = rated motor ability
x = regression equation score from *general motor capacity* battery
y = regression equation score from *general motor ability* battery
i = Classification Index
a = age

	Boys	*Girls*
r_{cx} (Iowa City schools)	.9689	.9207
r_{rx} (Iowa City schools)	.5124	.7337
r_{xy} (Iowa City schools)	.7486	.6726
r_{xy} (Des Moines elementary school)	.7128	.5984
r_{xy} (Des Moines junior high school)	.8165	.5878
r_{xy} (Des Moines senior high school)	.7161	.5093
r_{xi} (Des Moines elementary school)	.7772	—
r_{xi} (Des Moines junior and senior high schools)	.8628	—
r_{xa} (Des Moines elementary school)	—	.4107
r_{xa} (Des Moines junior high school)	—	.0965
r_{xa} (Des Moines senior high school)	—	.0001

A FACTOR ANALYSIS OF THE TEST

Thurstone[13] has recently made available a most valuable method of multiple factor analysis. This method analyzes any battery of tests for its common elements. For example, in this battery strength is undoubtedly one factor which is common in varying degrees to every element in the test, yet it will be more important in the Sargent jump than in the Brace test. Either speed or velocity is a factor which is common to most of the items in the test, although it is somewhat more prominent in the Sargent jump and less prominent in the Brace test and slightly negative in the Classification Index. Thurstone's method enables one to determine the relative amounts of each of these factors that is possessed by individual elements of the test.

We have analyzed the four elements of the General Motor Capacity test by this method of factor analysis. We have added the element of pull-up strength, in one phase of this analysis, in order to include for our purposes one test which depended entirely upon either speed or velocity.

In this analysis we have isolated only three of the possibly larger number of "common factors," that is, those factors which are *common*

to two or more tests. In addition to such common factors each test will probably have one or more factors that are *specific* to that test alone (so far as this particular battery is concerned).

The five tests analyzed are listed in Table VI. Under the columns numbered I, II, and III, which correspond to the three common factors, and in the column for the specific factor are given the *correlations of each test with each factor*. It must be remembered that the specific factor comprises all that is *not* included under one of these three common factors. This analysis gives some idea of the components of each test. The first factor is undoubtedly strength; the second is velocity; the identity of the third is in doubt but is probably something like large-muscle coordination, although further studies will have to be completed before the identification can be made with certainty.

TABLE VI

FACTOR ANALYSIS OF GENERAL MOTOR CAPACITY TEST; CORRELATIONS OF TEST ELEMENTS WITH COMMON AND SPECIFIC FACTORS

Test	Factor I	Factor II	Factor III	Specific Factors
Sargent Jump	.3964	.6910	.0000	.6045
Burpee Test	.0830	.1855	.3441	.9167
Brace Test	.2737	.6643	−.1378	.6818
Classification Index	.8212	−.0658	−.3137	.4721
Pull-up Strength	.9519	.0000	.0000	.3064

It will be seen that (1) there is a very large specific element in the Burpee test; (2) there is a wide difference in the things tested by each separate test; (3) the first two elements in the Sargent jump and the Brace test are surprisingly alike in the size of their correlations with the common elements, but it is probable that the *specific* elements, which are present in fairly large amounts, are quite different in nature; (4) the strength test (pull-up strength) is almost entirely strength; and (5) the Classification Index is very highly correlated with strength. Other interesting aspects of the test will be apparent on studying Table VI.**

The *total score* of the General Motor Capacity test is analagous to the *gross score* of an intelligence test. The general motor capacity score will differ in significance for individuals of different ages and sizes. Therefore, we have interpreted this score in terms of a Motor Quotient which is analagous to the intelligence quotient in the field of mental testing.

It will be remembered that the intelligence quotient gives the intelligence of an individual in terms of a percentage of the average intelligence of a standard population group. This is based upon a comparison of

** This factor analysis of the General Motor Capacity test is only a preliminary investigation of this subject, although it is accurate as far as it has been carried out. It is presented here to show more clearly the nature of the "composition" of the individual tests. Further studies in this field will be published later.

"mental ages." In a somewhat analagous manner the Motor Quotient gives the general motor capacity in terms of a percentage of the average general motor capacity of a standard group.

The Motor Quotient has been developed on different bases for the two sexes. Owing to the relatively high correlations given by the Classification Index with various forms of fundamental motor ability, this

TABLE VII

FORMULAE FOR COMPUTING NORMS FOR THE MOTOR QUOTIENT

1. *Elementary school boys*
   .2327(Classification Index) — 29.9
2. *Junior and senior high school boys*
   .4316(Classification Index) — 149.3
3. *Girls, ages 8 to 11½*
   19.87(age in years and half years) + 236
4. *For all girls aged 12 and over*
   use 470 as the norm

index has been used as the basis for the Motor Quotient for boys. In other words, norms for general motor capacity have been developed for a regression equation based upon the Classification Index, and the Motor Quotient is simply one hundred times the actual motor capacity score divided by this norm,

$$M.Q. = \frac{100(\text{General Motor Capacity Score})}{\text{Norm for Classification Index}}$$

or in other words, it is the percentage relationship between the individual's general motor capacity and the average general motor capacity for boys of the same Classification Index.††

For girls the problem is an entirely different one owing to the fact that the elements of age, height, and weight have almost no relationship, as was pointed out above, to the motor performance of this sex. In the age range below eleven and one-half years, age alone is of significance. Hence, the Motor Quotient for girls is based upon the norm for age up to and including eleven years; beyond that age it is based on the average for twelve years and over. Standards for computing the Motor Quotient are given in the formulae in Table VII.

SUMMARY

TEST OF GENERAL MOTOR CAPACITY

1. This test is intended to measure as accurately as possible the innate potential general motor capacity.

2. The test is in the form of four separate test elements (counting the combined track and field events as one element), each of which gives

†† For the benefit of those statistically inclined, it may be said that the regression of general motor capacity on the Classification Index is entirely linear and the correlation is .8628 for the high school range and .7025 for the elementary school.

specific information useful in itself. There is a gross score which is an index of general motor capacity, and there is a computed score in the form of the Motor Quotient which interprets the general motor capacity score in terms of relative size and maturity of the individual.

3. This is not a test of specific skills or abilities. Events which demand a high degree of developed special abilities will usually correlate less highly with the test than those events which do not require such abilities. This is particularly true of events which require a specialized development in which might be called character qualities, such as physical courage, quick thinking, and aggressiveness, as found in football. Such traits have no relationship to this test. As a result the general motor capacity score correlates highly with track and field, but only correlates about .7 with football and basketball in high school groups. Therefore, this test should not be used to attempt to predict those things for which it is not designed. Its use should be restricted to the prediction of motor *capacity,* remembering that it will predict potential levels to which the individual may attain more accurately than it will test his present developed abilities.

GENERAL MOTOR ABILITY

In connection with the development of the General Motor Capacity score an attempt was made to devise a test of General Motor Ability, using "ability" in the sense of *developed capacity.* The concept of this *general* ability, however, required that the test avoid as much as possible highly specialized skills. This study is based upon a number of studies conducted at the State University of Iowa, and utilizes in addition the findings from the classical study of Rogers.[8]

Several studies of general motor ability have been conducted recently at the State University of Iowa. These studies differed in detail but were alike in that a large number of individual test elements were given, each correlating separately with the total test score.‡‡ These test elements were then analyzed to determine which ones gave the best correlations, both individually and in batteries, with the total score, which was taken as a criterion of general motor ability.

The studies agreed in pointing out that there were two types of tests, excellence in which is accompanied by excellence in almost all other abilities that could be expected to measure general motor ability. These tests were: (1) a combination of three or four track and field events scored in points, together with (2) a strength test. These two tests gave as high a prediction of general motor ability as was given by any other combination of events. Other items added to this battery gave no other significant additional predictive value.

In a number of studies conducted at this institution, pull-up strength,

‡‡ Using the same research technique as that used by Dr. F. R. Cozens in his study, "The Measurement of General Athletic Ability in College Men."

as computed by the author's formula, correlates in the neighborhood of .9 with total strength, as compted by the Rogers' formula but with the author's scoring of pull-up and push-up strength.[8a, 8c] There is a similar but not as high correlation with the number of pull-ups (not the pull-up strength) for girls.[9] We have combined in the General Motor Ability test the two elements involving arm strength and track and field athletic events.

For Boys.—In the present test for boys, arm strength is computed according to the author's formula.[11] The track and field events may vary with the age and experience of the group. However, they should be made up of one sprint (varying from fifty yards to one hundred yards), one broad jump (either running or standing), the running high jump, and a weight-throwing event. This may be either the shotput, throwing the basketball for distance, or throwing the baseball for distance. These four events should be scored on the author's scoring tables,[1] and the sum of these scores taken as track and field points. The formula for combining these events is given in Table IV.

For Girls.—In the girls' General Motor Ability test the actual number of pull-ups is used rather than pull-up strength. The rules for administering the pull-ups are those given by Rogers, with the exception that a bar is used instead of rings and the height of the bar is kept within an inch of the height of a girl's xiphoid cartilage when she is standing. Three track and field events are used: a sprint, a broad jump, and a throw. These are scored upon the scoring tables referred to above. The formula for combining these elements is given in Table IV.

In computing the weighted formula for the General Motor Ability tests for boys and girls, the method of multiple regression was used, the correlations being made against the same criterion used for the General Motor Capacity, except that the intelligence quotient element was removed.

This test may be taken as a measure of general motor ability as developed at the time the test is given, in contrast to the general motor capacity which measures the limit to which the subject *could be* developed.

In a previous unpublished study the author correlated total track and field points against the technical skill in soccer football and basketball of adult physical education professional students, all of whom had had the same number of years of training and experience. These estimates of technical skill were made by ratings, each individual in the group rating each other individual. The subjects were instructed to disregard elements of quick thinking and courage, and to rate only the technical motor skills. The resulting correlations with track and field were: basketball .92, soccer football .84. Apparently, then, these track skills of running, throwing, and jumping measure fairly accurately certain fundamental skills underlying motor abilities of a highly specialized type.

GENERAL MOTOR ACHIEVEMENT QUOTIENT

The general motor ability score, while it is a variable thing which increases with training but at a diminishing rate as one approaches his maximum, is related to the general motor capacity score; and the possible *maximum* ability score may be quite accurately predicted from the capacity score. Based on this fact, standards of "practical maxima" have been devised which locate the standard ability score at two standard deviations of estimate above the average general motor ability score for the individual's general motor capacity score.§§ It is obvious that a small number, about 2 per cent, will surpass this record. However, it is felt that a standard that is two standard deviations above the average is sufficiently high for all practical motivating purposes. Hence, we propose a General Motor Achievement Quotient which shall be one hundred times the actual general motor ability score divided by this "practical maximum" standard.

This quotient will be in terms of the *percentage relationship of the actual ability to the predicted or standard ability* and is not comparable to the usual type of achievement quotient in which one hundred is the average. In this case a boy having a general motor achievement quotient of ninety can be told that his achievement is 90 per cent of what it should be if he was developed as well as could be expected for age and general maturity.

To facilitate the computation of this quotient the formulae for the general motor capacity score and for the general motor ability score have been equated in such a manner that the general motor capacity score *is* the "practical maximum" of general motor ability for all groups except elementary school girls. For this group the general motor capacity score minus 90 is the "practical maximum" standard. Hence, the general motor achievement is simply one hundred times the general motor ability score divided by the general motor capacity score.

This General Motor Achievement Quotient can be used for motivating practice, for assigning grades, supplemented, of course, by other criteria, and for determining the *relative* level of achievement so far as motor development is concerned. In a word, this is an estimate of "how good he is for how good he could be."

It should be noted that the General Motor Achievement Quotient is an *achievement* quotient, or a quantitative statement of the relationship that exists between his developed motor ability and his innate motor capacity. This quotient is subject to change with improvement in performance. The Motor Quotient, on the other hand, is purely a *relative capacity* score, indicating quantitative relationship between *his* capacity and the *average* capacity for boys of his age and size; and present evi-

§§ In statistical terminology this "practical maximum" standard is two standard deviations of estimate above the regression line of general motor ability on general motor capacity.

dence, while as yet inconclusive, indicates that the quotient is relatively stable for each individual.

ADMINISTRATION OF THE TESTS

The method of conducting the tests has been published elsewhere.[10] The Sargent jump and the Burpee test should be taught until the form has been properly learned. This procedure ordinarily takes only five or ten minutes for the Burpee test but may consume one-half dozen ten-minute periods for the Sargent jump. It is important that this practice be given for the performance in the Sargent jump varies as much as 15 per cent with small differences in the arm swing.

In the author's opinion, the General Motor Capacity test should be administered about every three years. This test has not been available long enough as a battery to determine how much change will take place in the general motor capacity test within such a period, but experience with giving both the General Motor Capacity and the General Motor Ability tests before and after an intensive training period of four months indicates that the *capacity* test score changes little, but that the *ability* test score changes considerably. This is as would be expected.

The motor *ability* test can be given as often as the instructor desires, and the results can be compared with the original capacity score. If the motor capacity test is given only periodically, as we have suggested, the most probable value for the increasing motor capacity of the growing child can be interpolated by multiplying the *normal* motor capacity score for the Classification Index *at any given time* by the motor quotient computed at the last test. The same can be done for girls, using age instead of the Classification Index as the standard. For girls whose last test was taken at the twelfth birthday or later, the last General Motor Capacity can be assumed to be the correct one until the time of the next test.

SUMMARY

TEST OF GENERAL MOTOR ABILITY

1. This test is intended to measure as accurately as possible the actual general motor ability.

2. The test is composed of a simple test of strength and a battery of track and field events, which have been found in our studies to be highly valid measures of general motor ability.

3. The score is a gross score, not related to age or size. The score can be converted into a General Motor Achievement Quotient by dividing one hundred times the general motor ability score by the general motor capacity score..

4. The General Motor Achievement Quotient represents the ability of the subject *in terms of a percentage of a theoretical maximum standard score.*

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A Study of the Respiration of Golfers During the Drive and the Putt

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IN ACQUIRING skill in any sport there are certain physiological adjustments which must be made. In some instances these adjustments are learned through practice; in other instances these adjustments are acquired as a part of a natural reflex pattern resulting from the acquisition of skill.

When we think of respiratory adjustments in sports we are inclined, and rightly so, to look upon these alterations as pertaining chiefly to ventilation. It is true that the question of ventilation is an important one in sports, yet we must not overlook the respiratory alterations where ventilation is not the chief factor but where attention is the dominating process.

Little attention need be paid to ventilation in exercise since respiration is controlled by an automatic mechanism as long as man is in his natural environment. It is believed that the same holds true for respiratory adjustments in acts of skill requiring attention. If this is true, then one need pay no more attention to respiratory adjustments in acts of skill than in exercise.

It is known that with increased muscular effort there is an increase in respiration which is not an individual characteristic but a universal one. The question naturally arises whether the respiratory adjustments which are made in performing acts of skill are individual peculiarities or are common to everyone. This is the question to which we have directed our attention in this research.

In order to secure data relative to the respiratory habits of golfers, a technique was devised.

TECHNIQUE

The technique devised for studying the respiration of golfers required a method for recording the respiratory movements, one for recording the respiratory movements, one for determining the beginning of the back swing, and a means for indicating the moment of impact.

Recording Respiration.—The pneumograph was not considered as an instrument for recording respiration since it has been definitely

proved that where muscular movements of the chest are involved reliable records cannot be obtained.[1]

In order to avoid muscular disturbances, an ordinary respiratory mask was placed over the face and attached to a recording tambour. In the opening in one side of the mask a rubber stopper was placed with a glass tube in it. This opening served as an inlet for air. The size of the hole was governed by the amount of air required by the individual. It was always made large enough so that insufficient ventilation was avoided. A second stopper was placed in the other opening in the mask. A rubber hose thirty feet long was attached to a glass tube inserted in the latter stopper and connected to a tambour as shown in Plate I, Figure 1R. On inspiration the air flowed in through the open side of the mask. At the same time there was a reduction of pressure in the air line leading to the tambour. This caused the recording lever to be pulled down. On expiration the air was expelled, at the same time causing an increase in pressure in the air line to the tambour, thus moving the recording lever upward. This open-air recording device was checked for lag with the pneumograph method while the subject was quiet. The result of the check showed that when there was a difference, the lag was less with the open-air method than with the pneumograph technique.

The face mask was tightly attached to the subject so that air did not escape around the edges. When the mask was properly adjusted, the tambour lever moved up on expiration and down on inspiration. If the breath was held during inspiration, the tambour lever returned up to its base line; when the breath was held in expiration the lever moved down to its base line.

Determination of the Beginning of the Back Swing.—In order to determine when the back swing of the putting iron began, the apparatus illustrated in Plate II, Figure 3, was devised. A brass plate (b), three inches by one and one-half inches, was placed on the ground behind the ball. This plate was connected to one side of a dry cell as indicated by (+). The metal portion of the putter was connected to the other side of the dry cell through a signal magnet (Plate I, Figure 1, 2R) by means of a very fine copper wire wound around the shaft of the club up to the grip and thence back under the subject's arm. When the putter was placed in position addressing the ball it contacted the brass plate thus closing the signal magnet circuit. When the club was lifted for starting the back swing this contact was broken and is so indicated in the signal magnet record Plate I, Figure 1, 2R. While addressing the ball for the putt, the subject may have contacted the brass plate a number of times. However, the last contact indicated marked the beginning of the back swing just before the moment of impact.

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[1] T. M. Aycock, L. H. Graaff, and W. W. Tuttle, "An Analysis of the Respiratory Habits of Trained Swimmers," RESEARCH QUARTERLY, III: 2 (May, 1932), 199–217.

The method of marking the beginning of the back swing of the driver was exactly the same as described for the putter. The set-up is shown in Plate II, Figure 4.

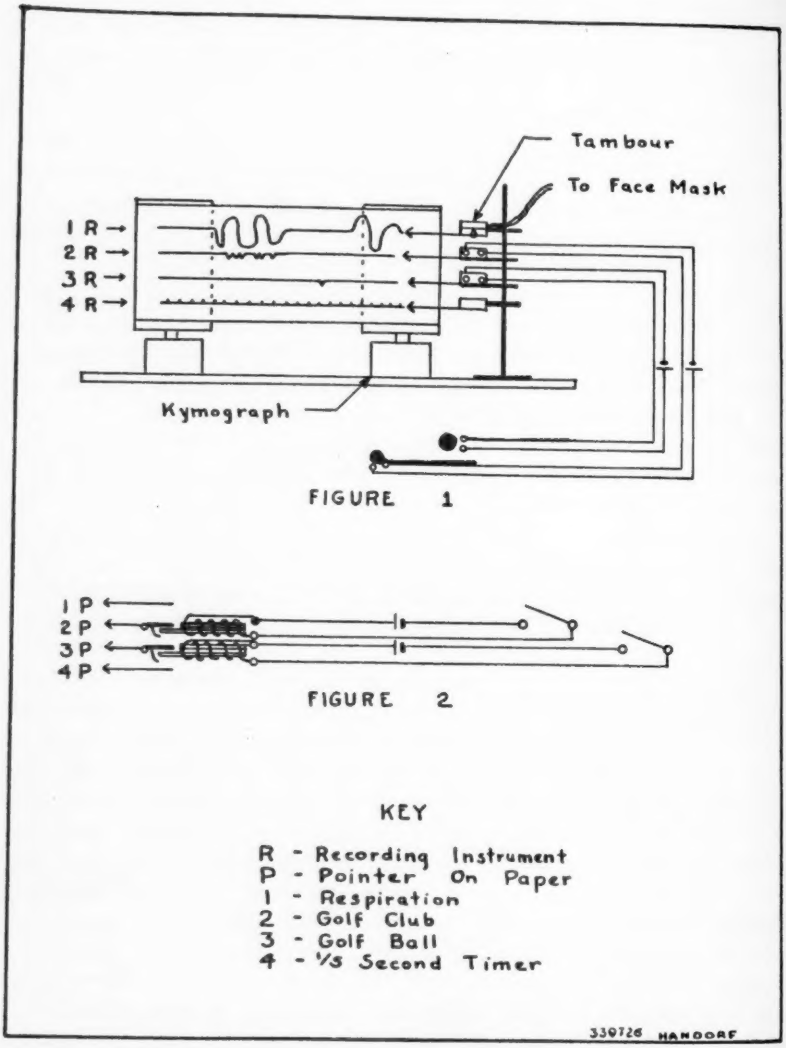

PLATE I.—The arrangement of the apparatus for graphically recording respiration during the drive and the putt.

Determination of the Moment of Impact.—In order to determine the moment of impact the apparatus was arranged as shown in Plate II, Figures 3 and 4. Two screws (f) were placed in the golf ball (e).

These were connected by a fine copper wire (g). An ordinary tee (j) was modified as follows: The top of the tee was rounded out with a countersinker. A drop of solder was placed on the end of a fine insulated

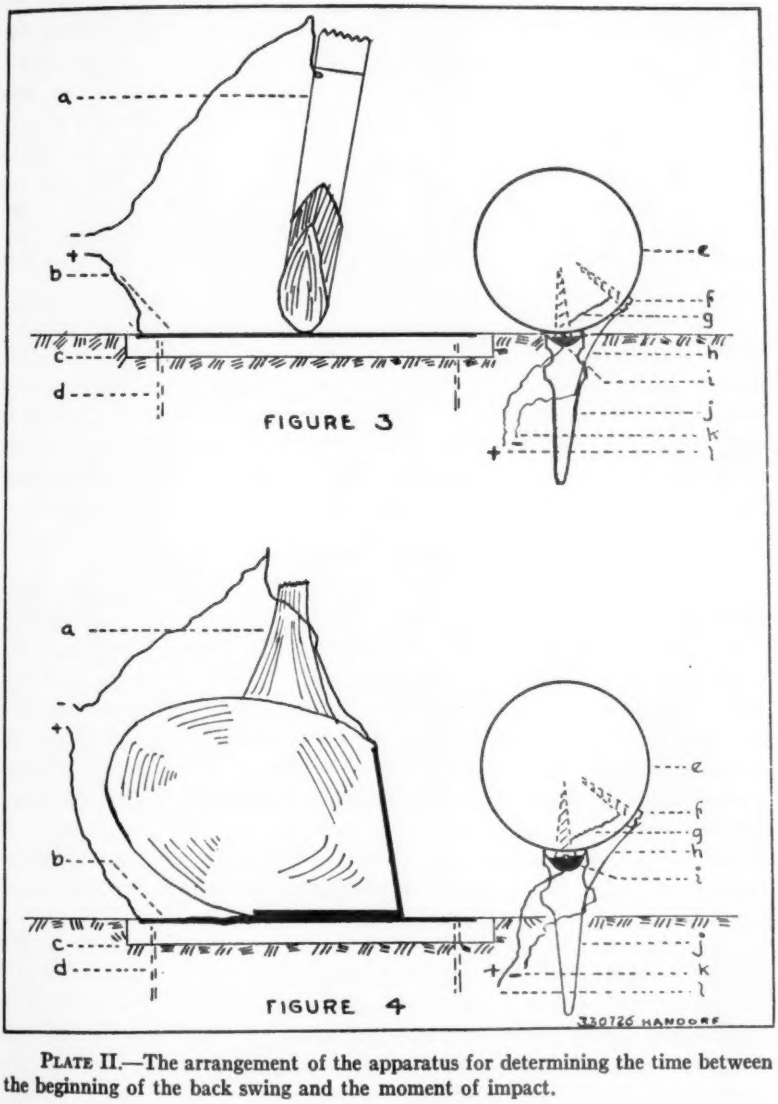

Plate II.—The arrangement of the apparatus for determining the time between the beginning of the back swing and the moment of impact.

copper wire (l) which was inserted through the side of the tee so that the drop of solder was in the top. A second piece of copper wire (k) was inserted through the tee and allowed to extend up to the side of the

ball. The hole in the top of the tee was filled with mercury (i). The ball was placed on the tee so that the head of one of the screws in it made contact with the other screw head through the mercury. The wire (k) was attached to one side of a dry battery. The wire (l) was connected through a signal magnet (Plate I, Figure 1, 3R) to the other side of the cell. As soon as the ball was placed in position, the signal magnet circuit was "made"; as soon as the ball was moved, the signal circuit was "broken," as indicated in the record shown in Plate I, Figure 1, 3R.

The set-ups for the putt and the drive were exactly the same, except that, for the putt the ball was level with the green, while for the drive it was teed up in the usual manner. Since the subject stood at the side of the ball, he was unconscious of any changes from a normal situation as far as the ball was concerned. Time was recorded in fifths of a second by means of a Jaquet chronograph (Plate I, Figure 1, 4R).

When all was in readiness the mask was adjusted to the subject's face and he proceeded to drive or putt in his usual manner. Experience showed that with but few exceptions the apparatus did not interfere with the subjects. Where they were conscious of interference, or when the record showed interferences, the experiment was discontinued. In each case the subject was observed and questioned as to his respiratory habits. Data thus secured were checked against the graphic record.

THE DATA

Data were collected from ten trained male golfers and nine who were untrained, six of whom were women. All subjects designated as trained were members of competitive teams and were able to shoot the University golf course, par seventy-four, at eighty or under. The untrained group included those who did not make a practice of playing golf and who had had no instruction in the game. The number of records made from each subject depended upon their character. Where all the records were identical not more than six were obtained. Otherwise a greater number was made in an attempt to establish the respiratory pattern. It is important to note that after a golfer has established a definite respiratory pattern for either the drive or the putt there are seldom any variations from it.

The Drive: Trained Group.—The respiratory pattern of six of the trained subjects during the drive was as follows: The back swing was started at the end of a deep inspiration. The breath was held after inspiration during the down swing and until the "follow through" was completed. After this a deep expiration occurred. In these six cases the respiratory pattern was identical for every drive. The graphic records obtained from three of this group are shown in Plate III. In the figure (A) represents the beginning of the back swing, and (B) the moment of impact. The *x*'s show the trial contacts made addressing the ball previ-

ous to the beginning of the back swing. It is important to note that the subjects had given no attention to their respiratory pattern during the drive; in fact, they were not at all aware of what it actually was.

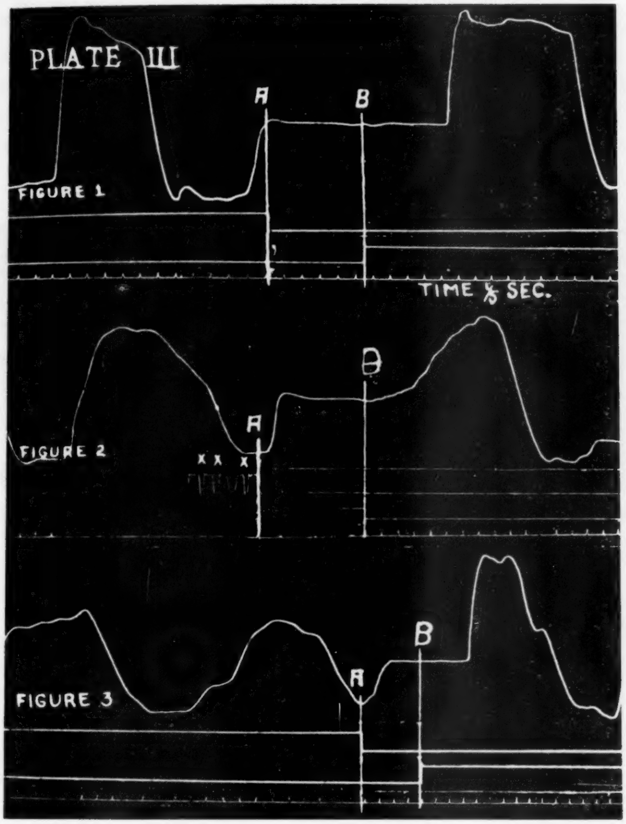

PLATE III.—Typical records of the respiration of trained golfers during the drive.

It was impossible to get valid records from two of the subjects due to the fact that their respiratory pattern was altered by the apparatus. The reason for this seemed to be the temperament of the individuals since they did not know the nature of the record that was being made. However, observations and the verbal report of these men established the fact that their normal respiratory pattern during the drive was as follows: At the end of a deep inspiration the back swing was started. The breath was held after inspiration during the down swing and until the "follow through" was completed. After this a deep expiration occurred.

There were two cases of special interest. For some reason these individuals had a preconceived idea that the proper respiratory pattern during the drive was as follows: After a deep inspiration a portion of the air was expelled and the breath held in this phase. At the end of this partial expiration the breath was held during the back swing, the moment of impact and the "follow through." When the stroke was completed the remaining air was expelled. A graphic record of this type of respiratory pattern is shown in Plate IV. It is evident that by continuous practice these individuals have developed the exceptional respiratory pattern just described.

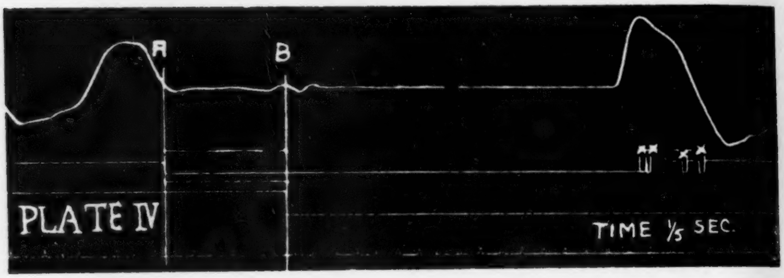

PLATE IV.—A record of a learned respiratory pattern which is unnatural for a trained golfer during the drive.

The Putt: Trained Group.—In the case of the putt of trained subjects, one of the prominent features of the respiratory pattern was its shallowness. Three of the subjects held the breath after a partial expiration. During this hold the putt was executed after which the expiration was completed. It was of interest to note that two of these subjects were the ones who drove during the hold of a partial expiration. This type of respiration during the putt is shown in Plate V, Figure 2. In two cases the putt was executed while the breath was being held after inspiration. This type of pattern is shown in Plate V, Figure 3. One subject executed the putt while holding the breath after inspiration part of the time and after expiration at other times. In four cases there were no alterations in the respiratory phases during the putt. However, the respiration of these subjects became perceptibly shallower. This type of respiration during the putt is presented in Plate V, Figure 1.

The Drive: Untrained Group.—Six subjects of the untrained group exhibited a respiratory pattern in driving a golf ball exactly like that of the trained subjects. There was no regular respiratory pattern which could be detected in the three remaining cases. In the case of the six who drove while holding their breath after inspiration, all were well trained athletes. They were proficient in such sports as archery, tennis, and baseball. In all of these activities there exist situations such as striking a ball,

or aiming and shooting, which are comparable to driving a golf ball. This behavior on the part of these subjects strongly suggested that there was a respiratory pattern "carry-over" from one sport to another.

The Putt: Untrained Group.—In seven cases there were no alterations in the respiratory pattern during the putt except that it became much shallower than normal. In two cases the putt was executed during a prolonged expiration.

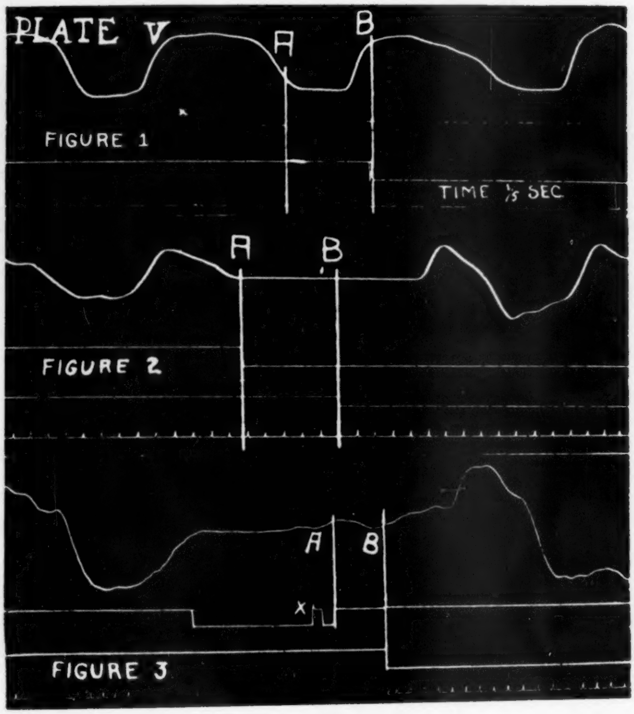

PLATE V.—Typical records of the respiration of trained golfers during the putt.

Time Consumed in the Drive and the Putt.—In order to show the time factor involved in the drive and the putt, Table I is presented. The time as indicated in seconds in the table represents the interval between the beginning of the back swing and the moment of impact. It is evident from the table that the time consumed in executing the drive and the putt was practically the same, one second. In the case of the untrained group a little more time was consumed in the drive as a rule.

The most significant thing about the time element was the consistency of the trained golfer. In one-half of the cases the time consumed in each

drive recorded was exactly the same and in no case did it vary more than 0.2 seconds. In four cases the times consumed in the putt were equal, the variation never being more than 0.2 seconds.

Among the untrained group there was no variation in the time consumed in the drive in two cases while there was a variation of 0.2 second in three cases. These were among the athletic group who had typical respiratory pattern. The remaining variations amounted to as much as 0.6 second. For the putt there was a marked inconsistency in the time consumed.

TABLE I

THE MEAN TIME CONSUMED IN THE DRIVE AND THE PUTT, AND THE RANGE FOR A SERIES OF SHOTS

Trained Golfers						Untrained Golfers				
Sub. No.	Score	Drive sec.	Range sec.	Putt sec.	Range sec.	Sub. No.	Drive sec.	Range sec.	Putt sec.	Range sec.
1	80	0.9	0.2	0.8	0.2	11	1.2	0.6	1.0	0.6
2	75	1.2	0.0	1.2	0.2	12	1.3	0.2	0.7	0.2
3	74	1.2	0.2	0.9	0.2	13	1.0	0.0	1.1	0.4
4	80	1.3	0.2	1.0	0.0	14	1.5	0.2	1.4	0.2
5	77	1.0	0.0	1.0	0.0	15	1.3	0.2	0.6	0.2
6	77	0.9	0.2	0.8	0.0	16	1.6	0.4	1.4	0.6
7	74	1.1	0.2	1.0	0.0	17	1.0	0.0	1.0	0.2
8	77	1.0	0.0	1.2	0.2	18	1.1	0.4	1.0	0.4
9	77	1.0	0.0	1.2	0.2	19	1.2	0.4	1.2	0.2
10	77	0.8	0.0	0.8	0.2					
Mean		1.0	0.10	1.0	0.12		1.2	0.27	1.0	0.33

SUMMARY AND CONCLUSIONS

A technique was developed for graphically recording the respiratory movements during the drive and the putt. By means of this technique data were collected from ten trained and nine untrained subjects. The following conclusions were drawn from the data:

1. Skilled golfers showed the following respiratory pattern: After a deep inspiration the breath was held. Either late in this inspiratory phase or at the end of it the back swing was started and the swing finished while the breath was held. The end of the swing was followed by a deep forceful expiration. This respiratory pattern was common to all the trained golfers studied except those who had consciously modified it. This natural respiration came into existence without any voluntary attention on the part of the individual.

2. The respiratory pattern of trained golfers in the putt was not as clear-cut as in the drive. In every case the respiration was shallower than normal. In the majority of cases the stroke was executed while holding the breath either following inspiration or expiration. However, four of the group showed no alteration in the inspiratory-expiratory phases.

3. Untrained subjects who have had no training in sports presenting situations similar to the drive and the putt have no definite respiratory pattern.

4. Unskilled subjects who are proficient in sports which have situations similar to driving and putting presented a respiratory pattern identical with that of a trained golfer. It was evident that this type of pattern has been developed elsewhere and "carried over" into the golf shots.

5. It required approximately one second to execute either the putt or the drive for both the trained and untrained golfer.

6. The trained golfer had a more uniform swing than the untrained as shown by the variability of the time range while putting and driving. In both cases, the mean variation of the untrained golfer was about three times that of the expert performer.

Factors Contributing to Speed in the Start of a Race and Characteristics of Trained Sprinters: A Summary of Experimental Investigations

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SPEED is the important factor in winning races, especially those of short distances, the so-called sprints, hurdle events, and the relays. Winning a race depends, other things being equal, upon the speed of competition. If I run the 220-yard dash ordinarily in 22.8 seconds, and run against an opponent whose time for the distance ordinarily is 22.1 seconds, I will be beaten. Eliminating any discussion involving "fate," "the breaks," "luck," factors which cannot be foreseen, controlled, or eradicated, let us consider some of the things a short distance runner should know relative to how his time can be decreased, or his speed increased, in his event.

Since speed is the most significant part of a race inquiries should be made as to the factors in the start of a race which contribute to speed. Only recently has the complex problem of the start of the sprint been approached experimentally. What has heretofore been merely conjecture has been put to the test and scientifically scrutinized. The researches have been truly experimental, i. e., the results of one variable have been studied while all others have been rigidly controlled.

Since the investigations have been on the effects of certain variables on starting time, the question, "What is starting time?" should be answered. Nakamura*[1] defined starting time as the time elapsing between the gunshot and the instant the hands of the starter broke contact with the track; Walker and Hayden[2] defined it as the time elapsing between the gunshot and the instant contact was broken with the foot back; Dickinson[3] defined it as the time elapsing between the gunshot and the instant contact was broken with the foot front. It can be determined readily that starting time is an arbitrarily defined period, which, except for purposes of each investigation, has no absolute value. Furthermore, it is evident that the starting times reported in each study are not comparable. When studying the effects of a certain variable, such as spacing of the feet, it

* Numbers refer to bibliography at end of article.

makes little difference just how starting time is defined for the basis of comparison, as long as it is kept constant.

What are the methods of measuring starting time? When once defined, precision apparatus can be set up for this purpose. Such apparatus has been described by Nakamura[1] and Tuttle and Bresnahan.[4] They used a chronoscope for recording time elapsed, contacts for either the hands or for the feet, or for both, and a signal magnet which recorded either at the instant the starting gun trigger was pulled or the sound of the gun occurred.

I. FACTORS CONTRIBUTING TO SPEED IN THE START OF THE RACE

Table I gives a summary of the findings of the various investigations pertaining to the start of a race. Each study will be discussed separately.

TABLE I

COMPARISON OF THE EXPERIMENTAL FINDINGS WITH RELATION TO THE TYPES OF STARTS USED

	Elongated	Medium	Bunch	Natural
Holes versus blocks:				
Hayden & Walker ....:				
Holes				168.0 sigma
Blocks				134.3 sigma
Position of the feet:				
Dickinson ....:	387.0 sigma	326.0 sigma	244.0 sigma	280.0 sigma
Block front to line ..	12.7 in.	15.1 in.	19.8 in.	17.9 in.
Block back to line ...	39.5 in.	35.6 in.	30.3 in.	31.4 in.
Distance between ...	26.8 in.	20.5 in.	10.5 in.	13.9 in.
Drive from legs:				
Kistler ....:				
Foot front force	196 lbs.	190 lbs.	195 lbs.	190 lbs.
Foot back force	208 lbs.	196 lbs.	151 lbs.	173 lbs.
Total force exerted ..	404 lbs.	386 lbs.	346 lbs.	363 lbs.
Dist. between blocks.	25.5 in.	20.5 in.	10.7 in.	15.4 in.
Size of man and position of feet:				
Dickinson ....:				
Tall men (6 feet, 1 inch)				
Foot front to line ..	14 in.	16 in.	21 in.	18 in.
Foot back to line ...	42 in.	37 in.	32 in.	31 in.
Short men (5 feet, 8 inches)				
Foot front to line ..	11 in.	13 in.	18 in.	17 in.
Foot back to line ...	37 in.	33 in.	28 in.	29 in.
Speed over a distance:				
Dickinson ....:				
Seven and one-half feet	887.0 sigma	878.0 sigma	808.0 sigma	——

A. HOLES VERSUS BLOCKS.

The use of starting blocks, as compared to the use of holes in the ground for starting, yielded the faster starting reaction times, according to the findings of Hayden and Walker.[5] Starting time was defined as the time elapsing between the gunshot and the breaking of contact of the

foot back. The reasons that the use of starting blocks resulted in the faster starting times is obviously that, first, starting blocks are on the surface of the ground, second, the starting blocks are more stable, i.e., do not "give" as much as the earth, and, third, the first movement is more forward and less upward than the movement resulting from the holes in the ground.

B. TYPES OF STARTS.

The use of the bunch, as compared with the natural, medium, and elongated starts, always resulted in the fastest starting reaction times, according to the findings of Dickinson.[3] In the bunch start the front block was on the average 19.8 inches from the starting line, being 2 inches, 4.7 inches, and 7.1 inches farther back than in the natural, medium, and elongated starting positions, respectively; the back block was on the average 30.3 inches from the starting line, being 1 inch, 5.3 inches, and 9.2 inches closer to the starting line than in the natural, medium, and elongated starting positions, respectively; the distance between the blocks was 10.5 inches, being 3.4 inches, 10 inches, and 16.3 inches less than the space between in the natural, medium, and elongated starting positions, respectively. Under types of starting positions come three other investigations.

1. *Leg Drive.*—Kistler[6] measured the drive of each leg in the start of the sprint by measuring the pressure exerted by each foot on the starting blocks. When the elongated start was employed, greater pressure was exerted by the foot back; when the medium start was used, the pressures exerted by both feet were about the same; when the bunch start was used, greater pressure was exerted by the foot front; and when the natural start was used, greater pressure was exerted by the foot front, but the difference between the pressures exerted by the two feet was not as great as that between the two feet when the bunch start was used. The use of the elongated start resulted in the slowest starting reaction time; use of the medium start resulted in a slightly faster starting time; use of the natural start resulted in a still faster starting reaction time; and use of the bunch start resulted in the fastest starting time.

It was found that hardly ever does the natural start of a sprinter approximate the elongated, seldom does it approximate the medium, but more often does it simulate the bunch start. In some cases it was found that the natural start was more extreme than the bunch start, i.e., the distance between the feet was less. Nakamura[1] stated that the greater force was exerted by the foot back. Assuming that he allowed his sprinters to use their natural starting positions, his statement does not agree with the experimental findings of Kistler.

2. *Physical Measurements* (*Size of Man*).—The average height of the short sprinters was determined and found to be 5 feet, 8 inches; for the tall sprinters to be 6 feet, 1 inch. Trunk length for the short men

was 27 inches, for the tall men, 29 inches; arm length for the short men was 27 inches, for the tall men, 29 inches; leg and thigh length for the short men was 34 inches, for the tall men, 39 inches; average weight for the short men was 145 pounds, for the tall men, 168 pounds.

In the elongated, medium, bunch, and natural starting positions, the foot front of the tall man was, on the average, three inches, three inches, three inches, and one inch farther back from the starting line than for the short man; the foot back of the tall man was, five inches, four inches, four inches, and two inches farther back from the starting line than for the short man. This difference can be accounted for in the difference in height and leg and thigh length. The distance between the blocks, in the elongated, medium, bunch, and natural starting positions for the tall man was two inches, one inch, and one inch greater than for the short man. This variation can be accounted for in the shoe size of the tall man. These findings were made by Dickinson.[3]

3. *Speed Over a Distance.*—It was found by Dickinson[3] that when the bunch starting position was employed the sprinters covered a distance of seven and one-half feet in shorter time than when the other starting positions were used.

C. MENTAL ATTITUDE.

A third contributing factor to speed in the start of a race is the mental attitude of the sprinter.

When a person anticipates a simple stimulus his reaction time is shorter than when he does not, according to Cattell.[10] This is called direction of attention.

There are two types of reactors, according to Wundt,[11] which are the sensory type and the motor type. In the sensory type of reaction a subject concentrates on the stimulus. The analogy in track is a sprinter who concentrates on the sound of the gun. In the motor type of response a subject focuses attention on the response. The analogy in track is a sprinter who concentrates his attention on his muscular set, i.e., on getting away at the sound of the gun. When comparing these two types of reactors, it was found by Titchener[12] that the motor reactor's time was much shorter than that of the sensory reactor. What bearing the mental attitude has upon the start of a race is evident from this discussion. Other things being equal, the sprinter, who anticipates the gunshot but who concentrates on his muscular set and responds reflexly, will start faster than a sprinter who concentrates on the shot of the gun.

D. TIME BETWEEN THE "GET SET" SIGNAL AND THE GUNSHOT

A fourth contributing factor to speed in the start of the sprint is the optimum time a runner should be held in his marks before the gun is fired. It has been determined that the time elapsing between the com-

mand, "get set," and the firing of the gun should not be too short nor too long. It takes time for attention to reach its peak, and, after a certain optimum time, attention begins to fluctuate. Walker and Hayden[2] found that a sprinter's starting reaction time was shortest when a 1.6-second interval occurred between the "get set" signal and the gunshot, although the starting reaction time for the 1.4-second interval was approximately the same as for the 1.6-second interval. Nakamura[1] found that the starting reaction time was shortest when a 1.5-second interval was used. Therefore, it can be said that attention has reached its peak at approximately 1.5 second, and hence the starter of races should take this fact into consideration.

II. CHARACTERISTICS OF TRAINED SPRINTERS

Besides the factors in the start of a race contributing to speed which have been investigated, aspects, which might be classified as characteristics of trained sprinters, have been studied.

A. SEQUENCE OF MOVEMENT IN BREAKING CONTACTS WITH THE TRACK

Nakamura[1] stated that the hands were raised first in the start of a race and simultaneously, one forward and the other backward, depending upon the footedness of an individual; and that the foot back broke contact almost simultaneously with the breaking of contact with the hands. Bresnahan[13] found that the sequence of breaking contacts with the track was, for the right-handed individual, left hand, right hand, right foot, and then left foot, there being a short interval of time between each movement. For the left-handed individual, the sequence was right hand, left hand, left foot, and then right foot. This sequence of movement was stated by Bresnahan to be acquired during the training of a sprinter, quite naturally, and without any mention being made of what sequence was to be learned.

B. RESPIRATORY PATTERN

Another aspect of the start of a race which has been studied is the respiratory pattern of trained (and untrained) sprinters during the start. Felker[14] found that trained (and untrained rarely) sprinters breathed normally between the signals, "on your marks" and "get set," but at the command, "get set," completed any phase of respiration being executed at the time whether inspiration or expiration, took a normal inhalation, and held the breath until after the gun was fired. Before the command, "get set," breathing, it was stated, was a physiological process which served the purpose of ventilation; after the command, "get set," the factor of attention became paramount, and the physiological adjustment in respiration, i.e., holding the breath, was regarded as a concomitant with the attentive process. Although characteristic of trained sprinters in the "set" position, this phenomenon

must not be regarded as only common to this particular phase of the start of a race but common to any person in any situation when "paying" maximum attention.

C. REFLEX TIME

It has been found by Lautenbach and Tuttle[7] that the reflex time of a trained sprinter was considerably shorter than the reflex time of a trained distance runner, being .0986 and .1345 second, respectively. A high degree of relationship between speed in sprinting and reflex time was found ($r = .82$). Although reflex action is an involuntary response, where there exists a relationship as stated, training was determined as the chief factor involved. However, other things being equal, a prospective sprinter with short reflex time would be able, through practice and training, to cover a short distance faster than one with long reflex time.

D. REACTION TIME

It has been found by Westerlund and Tuttle[8] that the simple reaction time of a trained sprinter was considerably shorter than that of a trained distance runner, being .131 and .169 second, respectively. A high degree of relationship between speed in sprinting and reaction time was found ($r = .86$). A trained sprinter with fast reflex time has correspondingly fast reaction time, it was found. Scripture[9] found that the reaction time was one-third shorter for sprinters than for distance runners.

In the start of the sprint a runner must react as quickly as possible to the gunshot in getting off his marks, hence the bearing that short reflex and short reaction times have to contributing factors to speed in the start of a race. Simple reaction time is slightly less than starting reaction time due to the fact that in the start movement of the whole body is concerned.

SUMMARY AND CONCLUSIONS

The experimental findings pertaining to the factors contributing to speed in the start of a race have been accurately determined; one variable was studied while others were rigidly controlled. Characteristics of trained sprinters have been investigated accurately.

Factors contributing to speed in the start of a race are:

1. The use of starting blocks.

2. The use of the bunch starting position.

a) Drive is greatest with the leg front for either tall or short men with variations in the foot spacings.

3. The mental attitude of:

a) Anticipation of gunshot.

b) Concentration on muscular set to respond reflexly.

4. The time of approximately 1.5 second between the "get set" signal and the gunshot.

Characteristics of trained sprinters are:

1. The right-handed sprinter breaks contacts with the track as follows: left hand, right hand, right (back) foot, and then left (front) foot.

2. The trained sprinter breathes normally between "on your marks" and "get set"; takes a normal inhalation; holds the breath until after the gun is fired.

3. The trained sprinter has shorter reflex time than trained distance runners.

4. The trained sprinter has shorter reaction time than trained distance runners.

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The Construction of an Objective Test of Knowledge and Interpretation of the Rules of Field Hockey for Women[1]

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In conducting rating centers for umpires, the United States Field Hockey Association requires all candidates to pass a written examination on the rules. An inspection of sample examinations used in different localities showed great variety in form, emphasis, scope, and difficulty. Since these local written examinations are the basis for both local and national ratings, and successful candidates are recognized by the national organization, it seemed essential to have a uniform objective examination used for all the ratings. To provide such an examination was the purpose of this study.

PROCEDURE

After a study of methods best adapted to the selection of material for the test, a list of topics to be covered by test items was prepared. This list was based on (1) an analysis of previous tests in use at the various umpiring centers, (2) the official rulebook of the United States Field Hockey Association, and (3) the judges' rating sheet for the practical test given to umpiring candidates.

When a complete list of subjects covered by the rules had been prepared, as many statements as possible were made relating to each of the topics. Each of these was then put in as many and as varied objective forms as were practicable. Each of these items was later revised in an attempt to secure clearness and conciseness of statement. They were then rated by the expert opinion of a "National A" umpire as either "good," "fair," or "poor." All those classified as "poor" were eliminated.

Five steps comprised the organization of the individual items into three equivalent examination forms. This was begun by the filing of each item under its proper subject classification, using a card index system in which the subject classification for each particular item was noted on every card. After this had been completed, the cards in each subject group were again arranged according to the type of objective form in which the items were prepared.

The next procedure consisted of dealing the cards filed by subject and by type of question, into three sets. In order to provide chance arrange-

[1] From G. J. Grisier, The Construction of an Objective Test of Knowledge and Interpretation of the Rules of Field Hockey for Women. M.A. Thesis, July, 1933. On file in the library of the State University of Iowa, Iowa City, Iowa.

ment of items in regard to subject, the cards in each type classification were thoroughly shuffled.

The final step in the preparation of the test forms was the elimination, on the basis of the expert opinion of two "National A" umpires, of all questionable items still remaining in any of the three sets.

As a result of this method, three forms of the examination were prepared, each having approximately the same number of items on a given subject, and having the same number of questions of a given type, with chance arrangement of subject matter. Directions for taking the various types of questions were carefully worked out, with emphasis on clearness and simplicity of statement.

VALIDATION OF ITEMS

An unusual opportunity for validating the test questions existed in the fact that the rating plan provided a list of umpires who had already demonstrated their knowledge of the rules. On the other hand a number of students and players, having some knowledge of the game but who were not rated as officials, were reached through instructors and local umpiring chairmen. A group of volunteers, both rated and non-rated umpires, took the test at the National Tournament in Rye, in November, 1932.

As a result of these methods of distributing the tests, a total of 315 tests were returned in time to be included in the tabulations. Of this number, 51 rated umpires and 56 players took "Form A," making a total of 107; 56 rated umpires and 48 players took "Form B," making a total of 104; and 64 rated umpires and 40 players took "Form C," making a total of 104.

After the tests were returned and a scoring key constructed, the errors made on individual responses by the rated and non-rated groups were tabulated. The percentage of error for each group on each response was used as a measure of the validity of that item since it showed the degree to which the question differentiated between the two groups, thus indicating knowledge essential to good umpiring. On this basis all items were eliminated in which the percentage of error of rated umpires was equal to or greater than that of the unrated group or was not at least one-fifth less than the non-rated group. Also items in which no errors were recorded in either group were discarded.

RELIABILITY OF TESTS

After discarding items of low validity, each test was scored as two equal halves on the basis of alternate items. These scores were then used for the computation of the product-moment correlation coefficient for each form of the test, the coefficient in each case indicating the reliability of that particular form. It was found that these coefficients were for "Form A" .88, "Form B" .88, and for "Form C" .92, indicating a

fairly high degree of reliability of the items included in the three examination forms.

DISTRIBUTION OF TEST SCORES

The frequency curves for each of the three forms were somewhat irregular and skewed toward the high end of the scale, probably because most rated umpires and some inexperienced players have a very accurate knowledge of the rules. That the test forms do distinguish between rated and non-rated umpires as a group is shown by Table I.

TABLE I

SCORES OF GROUPS IN RELATION TO THE MEDIAN SCORE OF EACH FORM

Classification	"Form A" Above median	"Form A" Below median	"Form B" Above median	"Form B" Below median	"Form C" Above median	"Form C" Below median
National A	6	0	8	1	14	0
National B	12	1	13	1	10	2
Local B	12	2	9	5	15	3
Local C	11	7	10	9	10	10
All rated groups	41	12	40	16	49	15
Non-rated groups	12	44	13	35	3	37

REVISION OF TEST FORMS

The next step was to revise the test form as to subject and as to type of question in order that the number of items might be made more nearly equal, the original balance having been considerably distorted by the discarding of items of low validity. It was also necessary to make a revision of the tests to provide forms approximately equivalent in validity and degree of difficulty.

The first step in the procedure of revision was the re-sorting, according to original subject classification and type of question, of all items retained. Each group, as determined by subject classification, was then arranged according to difficulty as determined by the total percentage of error on each item.

The entire group of items was then divided into three sets of approximately equal value, dealing them by chance in so far as possible, but basing the selection also on the equal distribution of items according to subject classification, type of question, degree of difficulty, and validity as indicated by the percentage of error of rated and non-rated umpires.

RESULTS OF THE STUDY

The results of this study are quite practical in nature. Three forms, equivalent, within limits of the study, of an objective examination have been prepared which are available for the use of the United States Field Hockey Association in preliminary examination of candidates for umpiring rating. "Form A" has been used during the 1933 season.

Because of the seasonal nature of the sport it was not possible to secure results on the revised forms of the test within the eighteen months duration of this investigation. Test results from the season of 1933 will be of great assistance in standardizing all forms.

A Study of the Relationships of Certain Measures of Rhythmic Ability and Motor Ability in Girls and Women[1]

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THE STUDY of rhythm as a phenomenon of human behavior has long been of interest in various fields. It has been assumed in the teaching of motor skills that rhythmic ability has a close relationship to motor ability. In so far as these abilities were shown by the tests used, the purpose of the two studies was to investigate that relationship in (1) college women and (2) girls, from the ages of nine to eighteen. For measuring motor ability the Brace scale of motor ability tests was used. The measures of rhythm used were: Carl Seashore's test of perception of rhythm, Robert Seashore's test of motor rhythm, and an original practical rhythm test. For purposes of comparison a supplementary measure, called the coaches' estimate of motor educability, was used.

PROCEDURE

The tests were administered with controlled technique to 100 college women. They were selected at random from 3 groups: students electing dancing, students majoring in physical education, and freshmen in required physical education classes. The younger group consisted of 102 girls, 59 being selected at random from high school physical education classes, and 43 being selected from the fifth, sixth, seventh, and eighth grade classes. In these two groups it was impracticable to secure other measures than the Brace test and the two Seashore rhythm tests.

The Brace test and the Seashore rhythm tests are so well known as to need no further description. The practical rhythm test aimed to include large bodily movement and some of the elements of rhythm such as tempo, accent, stress, and intensity in such a way that the test would be relatively simple enough to be used in groups of little or no training as

1 From E. Lemon, A Study of the Relationship Between Certain Measures of Rhythmic Ability and Motor Ability in College Women. M.A. Thesis, June, 1932; E. Sherbon, A Study of the Relationship Between Certain Measures of Motor Ability and Rhythmic Ability in Upper Grade and High School Girls. M.A. Thesis, June, 1932. On file in the library of the State University of Iowa, Iowa City, Iowa.

well as trained groups. The test had two parts, the first part being concerned with rhythm patterns and the second with tempo.

In the first part the subject, either by beating on a drum or by stepping, expressed four different rhythm patterns: (1) a two-part pattern, long-short-long-short, in two-four time; (2) a three-part pattern, long-long-long, in three-four time; (3) a four-part pattern, long-short-long-long, in three-four time; and (4) a five-part pattern, short-long-short-long-long, in four-four time. This part of the test had three divisions. In the first division each of the patterns was beaten on a drum while the subject listened, after which she beat on the drum what she had heard. In the second the patterns were again beaten, in a different order, after each of which the subject stepped what she had heard. In the third each pattern was stepped, in an order not yet used, and the subject beat on a drum what she saw. Thus two of the stimuli for those patterns were auditory and one was visual.

The second part of the test had to do with tempo. Three tempos were sounded on a metronome. The settings on the metronome were 64, 120, and 184, and these 3 speeds gave 12, 22, and 32 beats, respectively, in 10 seconds. The subject listened to the metronome at each speed and then stepped as nearly as possible in the same tempo while the examiner counted her steps for 10 seconds.

The coaches' estimate of each subject was derived from a subjective classification of students by their instructors. The subjects were classified, on the basis of ease of learning and motor educability, into five groups, viz., inferior, below average, average, above average, and superior.

THE DATA

The results of these studies, in terms of coefficients of correlation determined by the Pearson product-moment formula, are presented in Tables I and II. The results of the tests were correlated for each of the three groups studied.

DISCUSSION

While there are no highly significant correlations, there is evidence of some relationship between all of the tests used except between the Brace test and the test for perception of rhythm, and between the Brace test and the test for motor rhythm. Throughout the groups twenty-one out of forty of the coefficients of correlation are at least four times their probable errors; while in the total group, the coefficients range from three to seven times the probable errors.

The relationships, between perception of rhythm and practical rhythm, between motor rhythm and practical rhythm, and between coaches' estimate and the Brace test, showed consistency in all groups.

The total group consistently showed higher correlations than did the smaller groups, as would be expected. The dancing group showed a somewhat higher relationship of abilities than either of the other groups.

The coaches' estimate correlated closely with the results obtained from the Brace test, showing a degree of positive correlation throughout all the groups. However, this was not as close as the correlation which Brace found in the case of children.

TABLE I

CORRELATION OF TEST RESULTS OBTAINED FROM COLLEGE GROUPS

	Zero Order of Correlations			
	Major Group	Dancing Group	Fundamentals Group	Total Group
r_{01}	.243 ± .14	.325 ± .11	.063 ± .12	.201 ± .06
r_{02}	.217 ± .10	.336 ± .11	.027 ± .12	.198 ± .06
r_{03}	.137 ± .11	.372 ± .11	.231 ± .11	.345 ± .06
r_{12}	.203 ± .10	.140 ± .02	.363 ± .11	.243 ± .06
r_{13}	.381 ± .09	.463 ± .09	.433 ± .09	.421 ± .06
r_{23}	.386 ± .09	.460 ± .10	.107 ± .01	.309 ± .06
C.E. r_0	.416 ± .09	.483 ± .10	.270 ± .01	.385 ± .06
C.E. r_1	.079 ± .11	.315 ± .11	.466 ± .09	.271 ± .06
C.E. r_2	.383 ± .08	.194 ± .11	.329 ± .11	.315 ± .06
C.E. r_3	.133 ± .11	.250 ± .11	.587 ± .08	.341 ± .06
	Coefficients of Partial Correlations			
$r_{01.23}$	.200 ± .10	.208 ± .12	.063 ± .12	.033 ± .07
$r_{02.13}$	.171 ± .10	.223 ± .11	.022 ± .12	.095 ± .06
$r_{03.12}$	.011 ± .11	.146 ± .12	.250 ± .11	.266 ± .06
	Coefficients of Multiple Correlations			
$R_{0.123}$	.298 ± .10	.437 ± .10	.258 ± .11	.361 ± .16

Key: Brace test of motor ability—r_0
Seashore test for perception of rhythm—r_1
Seashore test for motor rhythm—r_2
Practical rhythm test—r_3
Coaches' estimate—C.E.

TABLE II

CORRELATIONS OF TEST RESULTS OBTAINED FROM HIGH SCHOOL AND UPPER ELEMENTARY SCHOOL GIRLS

	Zero Order Correlation	
	Brace motor ability	Perception of rhythm
Perception of rhythm	.094	—
Motor rhythm	.134	.438
	Multiple Correlation	
Motor rhythm and perception of rhythm	.142	—

The practical rhythm test correlated more closely with each of the two laboratory tests than the latter did with one another. This test also correlated more closely with the Brace test than did either of the other laboratory tests. The significance of the practical rhythm test is shown by the partial correlations in Table I. When either laboratory test was correlated with the Brace test, the practical rhythm test being partialled out, the correlation coefficient became insignificant; when the labora-

tory tests were partialled out, the relationship between the practical rhythm test and the Brace test remained practically unchanged. Conversely, the multiple correlation of the Brace test with the three tests for rhythm showed a higher coefficient of correlation than with either of the laboratory tests alone. This was not appreciably higher than its correlation with the practical rhythm test alone.

CONCLUSIONS

The data obtained from these two studies justify the following conclusions:

1. There was a definite, although low, correlation between rhythmic ability and motor ability in college women, as measured by the four tests. The results with the younger groups, in which the practical rhythm test was not used, did not show this relationship. That the correlation was not highly significant may have been due to imperfections in the tests as well as a lack of common factors in the abilities tested.

2. The test for perception of rhythm is not an adequate test of the type of rhythmic ability emphasized in physical education activities. This is easily understood since no motor response is measured by this test.

3. The test for motor rhythm is not an adequate test for the type of rhythmic ability emphasized in physical education classes. It tests a limited motor response made to one simple rhythm pattern. This response involved only the small muscles of the hand and arm.

4. The practical rhythm test seemed to be a test of rhythmic ability more useful for our purpose than either of the laboratory tests. It has the element of perception of rhythm patterns in common with the test for perception of rhythm, and has the element of motor expression in common with the test for motor rhythm. In addition, it measures a general bodily response both to auditory and visual stimuli.

5. The coaches' estimate seemed to be justified as a supplementary measure of motor ability.

6. The higher coefficients of correlations, between the results of different tests administered to the dancing group, may have been due to the fact that primarily this group was interested more in rhythmic activities.

7. It is indicated by this study that rhythmic ability is more the result of innate tendencies than of training since the correlations of the results obtained from the major group, who had had training in rhythm and motor responses were no higher than those obtained from the other groups.

8. This study indicated the fact that a test such as the practical rhythm test may be of enough significance in measuring the rhythm of gross bodily movement to warrant further study of its possibilities. This is not apparent, however, in the study of the younger group in which the practical rhythm test was not used.

A Scoring Table for College Women in the Fifty-Yard Dash, the Running Broad Jump, and the Basketball Throw for Distance[1]

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IT IS undoubtedly true that the college woman who excels in some event on the track or field finds her own joy of achievement and a challenge to better performance when comparing her best achievement with the best recorded performance in that event in the world. Perhaps her best may not reach this peak of attainment, but at least she has the opportunity for reward as she outstrips her opponents of lesser ability in a throw, a run, or a jump. Those of us who have tried to teach the college student these fundamental skills of throwing, running, and jumping have had little trouble in securing her interest and effort. But what of the vast majority of girls who can hope neither to attain national distinction, nor to secure the satisfaction of defeating their own classmates? Would it not be an infinitely more valuable thing if we could get each young women in our schools to be interested in learning to develop to a fair degree her ability in these events, rather than to develop to a point as nearly perfect as possible the few girls who have a natural aptitude for track events?

In this study an attempt has been made to develop, by means of statistical treatment of data, scoring tables which will score and thus encourage to further practice, not only the girl who is already skilled, but also the girl who has had little practice or has little native ability in these events. It is believed that the Tables IV, V, and VI will provide for the scoring of any girl from the beginner to the expert.

It would seem that the tables could well serve both student and teacher in several additional ways. Among them may be mentioned the following:

A. *Uses to the Teacher.*—

1. To determine what can reasonably be expected of the untrained college woman in these events.

2. To test her own success as a teacher.

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[1] From A. V. Mitchell, A Scoring Table for College Women in the Fifty-Yard Dash, the Running Broad Jump, and the Basketball Throw for Distance. M.A. Thesis, July, 1932. On file in the library of the State University of Iowa, Iowa City, Iowa.

3. To serve as a means of classifying students.

4. To discover individual and group deficiencies in certain events so that more intensive practice may be given in these events.

5. To compare the progress of classes or groups.

6. To serve as an objective means of grading students according to their improvement.

7. To provide a means of competition or comparison with other institutions.

8. To check on the efficiency of previous training of college freshmen.

B. *Uses to the Student.*—

1. To show her where she stands in comparison with other students, that is, whether she is above or below average.

2. To check on her improvement and thus serve as a stimulus to greater effort and achievement.

3. To serve as a goal toward which to work.

4. To serve as a basis for comparison between achievement in one event and achievement in another.

A review of the literature showed that a number of scoring tables have been constructed.[2] However, in most of them, there has been no attempt to use statistical procedures. They have been based upon the judgment and experience of those who have compiled them rather than upon the objective treatment of data.

PROCEDURE

Six hundred college women, who were selected at random from six institutions,[3] were tested in the fifty-yard dash, the running broad jump, and the basketball throw for distance. Similar coaching and judging techniques were used. One trial was permitted in the dash, three in the jump, and three in the throw. The best trial was recorded.

TREATMENT OF DATA

The T-Scale is an accepted method of constructing a scoring table. It is most useful if data are homogeneous.[4] The frequency distributions in this study approached the normal curve and an investigation of three factors, age, height, and weight, showed little significant effect upon

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[2] A. R. Wayman, *Education Through Physical Education,* Chapter XVIII. Philadelphia: Lea and Febiger, 1925.

Official Handbook of the National Committee on Women's Athletics of the American Physical Education Association, Spalding's Athletic Library, 115R, pp. 103–107. New York: American Sports Publishing Co., 1925–26.

A. W. Frymir, *Track and Field for Women,* p. 186. New York: A. S. Barnes and Co., 1930.

[3] These institutions were: Kansas State Teachers College, Emporia; De Pauw University, Greencastle, Indiana; Hanover College, Hanover, Indiana; the State University of Iowa, Iowa City; Northern Normal and Industrial College, Aberdeen, South Dakota; Missouri State Teachers College, Warrensburg.

[4] C. H. McCloy, *Measurement of Athletic Power,* p. 11. New York: A. S. Barnes and Co., 1932.

scores as may be seen in Tables I and II. Training (defined as six or more weeks of instruction and practice in track and field events) affected the means as shown in Table III. Only 11.6 per cent of the whole group had had training in these events, and this factor could not be said to destroy the homogeneity of this group.

TABLE I
CORRELATION COEFFICIENTS (PEARSON PRODUCT-MOMENT)

	Height	Weight
Fifty-yard dash	$r = -.0117$	$r = +.0346$
Running broad jump	$r = +.0624$	$r = -.1150$
Basketball throw	$r = +.1411$	$r = +.1901$

TABLE II
MEAN PERFORMANCE OF AGE GROUPS

Age	No. of subjects	Arithmetic Means: 50-yard dash (sec.)	Broad jump (in.)	Basketball throw (in.)
22	11	8.63	102	472
21	24	8.49	107	492
20	48	8.55	110	463
19	136	8.49	111	481
18	176	8.45	111	433
17	59	8.64	107	490

TABLE III
MEANS OF TRAINED AND UNTRAINED GROUPS IN
THREE TRACK AND FIELD EVENTS

Event	Mean Performance: Trained	Untrained	Percentage superiority
Fifty-yard dash	7.6 sec.	8.6 sec.	112.0
Broad jump	10 ft. 6.6 in.	9 ft. 0.5 in.	116.7
Basketball throw	46 ft. 10.3 in.	38 ft. 7.6 in.	120.6

Therefore, the T-Scale was used, and scoring tables were constructed in the manner suggested by Brace.[5] It was felt that it would be desirable to carry the scoring table on to include the present world record in each event and to provide for possible improvements in these records in the future. This was done by plotting the actual performance against the T-Score and continuing the curve thus secured until it intersected the perpendiculars to the X-axis at the 0 and 100 points. The scale score from 0 to the lowest limit of our table and from the upper limit of our table was then read off and inserted to complete the T-Scale. In some cases the curve, obtained from plotting the performance against the T-Score,

[5] D. K. Brace, "A Method for Constructing Athletic Scoring Tables," *American Physical Education Review,* XXIX:4 (April, 1924), 162.

showed some irregularity at the extremities, especially in the case of the broad jump. This was probably due to the fact that nine individuals scored in the lowest step-limit of the distribution, thus causing some irregularity in the curve obtained. The irregularity in the upper part of the curve was perhaps due to the fact that in the fourth step-interval from the top of the distribution, the frequency dropped from 25 to 4 cases. The curve was smoothed to take care of these irregularities.

TABLE IV
SCORING TABLE FOR COLLEGE WOMEN
FIFTY-YARD DASH

Performance (sec.)	Score in points	Performance (sec.)	Score in points
14.0–14.1	0.0	9.4–9.5	39.5
13.8–13.9	2.0	9.2–9.3	41.5
13.6–13.7	4.0	9.0–9.1	43.0
13.4–13.5	6.5	8.8–8.9	45.0
13.2–13.3	8.0	8.6–8.7	47.0
13.0–13.1	9.5	8.4–8.5	49.0
12.8–12.9	11.0	8.2–8.3	51.5
12.6–12.7	13.5	8.0–8.1	54.5
12.4–12.5	19.0	7.8–7.9	57.0
12.2–12.3	20.5	7.6–7.7	59.5
12.0–12.1	22.0	7.4–7.5	61.5
11.8–11.9	23.0	7.2–7.3	64.0
11.6–11.7	24.0	7.0–7.1	67.0
11.4–11.5	25.5	6.8–6.9	70.0
11.2–11.3	26.5	6.6–6.7	73.5
11.0–11.1	28.0	6.4–6.5	76.5
10.8–10.9	29.0	6.2–6.3	79.0
10.6–10.7	30.0	6.0–6.1	82.5
10.4–10.5	31.5	5.8–5.9	87.5
10.2–10.3	33.0	5.6–5.7	91.0
10.0–10.1	35.0	5.4–5.5	94.0
9.8– 9.9	36.5	5.2–5.3	98.5
9.6– 9.7	38.0	5.0–5.1	100.0

CONCLUSIONS

The following conclusions have been drawn from the data collected:

1. Age had little effect upon performance in the running broad jump, the basketball throw, or the fifty-yard dash, for college women of the normal age range (seventeen to twenty-two years).

2. Weight had an almost negligible effect upon performance in the three events, having the greatest upon basketball, almost no effect upon performance in the fifty-yard dash, and a slightly negative effect upon performance in the running broad jump.

3. Height had an almost negligible effect upon performance in the three events, the greatest being upon performance in the basketball throw, almost none upon performance in the running broad jump, and a very slight negative effect upon performance in the fifty-yard dash.

4. College women, barring unusual differences in training, seem to be a homogeneous group and can thus be scored by means of a table constructed on the basis of the T-Scale.

5. The scoring tables resulting from this study present fair bases of comparing the performance of college women in three athletic events.

6. The applicability of the scoring tables is not universal, i.e., they do not apply to all age groups.

7. If carried on by the same methods, the study of other events would be of use in completing the scale so that the abilities of college women might be compared in all of the events in which they participate in track and field athletics.

TABLE V
SCORING TABLE FOR COLLEGE WOMEN
RUNNING BROAD JUMP

Performance	Score in points	Performance	Score in points
0 ft. 0 in. to 1 ft. 5 in.	0.0	9 ft. 10 in. to 10 ft. 2 in.	54.5
1 ft. 6 in. to 1 ft. 10 in.	1.5	10 ft. 3 in. to 10 ft. 7 in.	57.0
1 ft. 11 in. to 2 ft. 3 in.	5.0	10 ft. 8 in. to 11 ft. 0 in.	59.0
2 ft. 4 in. to 2 ft. 8 in.	8.0	11 ft. 1 in. to 11 ft. 5 in.	61.5
2 ft. 9 in. to 3 ft. 1 in.	11.0	11 ft. 6 in. to 11 ft. 10 in.	64.0
3 ft. 2 in. to 3 ft. 6 in.	14.0	11 ft. 11 in. to 12 ft. 3 in.	66.0
3 ft. 7 in. to 3 ft. 11 in.	17.0	12 ft. 4 in. to 12 ft. 8 in.	68.0
4 ft. 0 in. to 4 ft. 4 in.	20.5	12 ft. 9 in. to 13 ft. 1 in.	70.0
4 ft. 5 in. to 4 ft. 9 in.	22.0	13 ft. 2 in. to 13 ft. 6 in.	72.0
4 ft. 10 in. to 5 ft. 2 in.	24.0	13 ft. 7 in. to 13 ft. 11 in.	74.0
5 ft. 3 in. to 5 ft. 7 in.	28.0	14 ft. 0 in. to 14 ft. 4 in.	76.0
5 ft. 6 in. to 6 ft. 0 in.	31.0	14 ft. 5 in. to 14 ft. 9 in.	78.0
6 ft. 1 in. to 6 ft. 5 in.	33.5	14 ft. 10 in. to 15 ft. 2 in.	81.0
6 ft. 6 in. to 6 ft. 10 in.	36.0	15 ft. 3 in. to 15 ft. 7 in.	83.0
6 ft. 11 in. to 7 ft. 3 in.	38.0	15 ft. 8 in. to 16 ft. 0 in.	85.0
7 ft. 4 in. to 7 ft. 8 in.	40.5	16 ft. 1 in. to 16 ft. 5 in.	88.0
7 ft. 9 in. to 8 ft. 1 in.	43.0	16 ft. 6 in. to 16 ft. 10 in.	90.0
8 ft. 2 in. to 8 ft. 6 in.	45.5	16 ft. 11 in. to 17 ft. 3 in.	92.0
8 ft. 7 in. to 8 ft. 11 in.	47.5	17 ft. 4 in. to 17 ft. 8 in.	95.0
9 ft. 0 in. to 9 ft. 4 in.	50.0	17 ft. 9 in. to 18 ft. 1 in.	97.0
9 ft. 5 in. to 9 ft. 9 in.	52.0	18 ft. 2 in. to 18 ft. 6 in.	98.5
		18 ft. 7 in. to 18 ft. 11 in.	100.0

TABLE VI
Scoring Table for College Women
Basketball Throw for Distance

Performance	Score in points	Performance	Score in points
0 ft. 0 in. to 3 ft. 11 in.	0.0	48 ft. 0 in. to 49 ft. 11 in.	59.0
4 ft. 0 in. to 5 ft. 11 in.	3.5	50 ft. 0 in. to 51 ft. 11 in.	60.5
6 ft. 0 in. to 7 ft. 11 in.	7.0	52 ft. 0 in. to 53 ft. 11 in.	62.5
8 ft. 0 in. to 9 ft. 11 in.	10.5	54 ft. 0 in. to 55 ft. 11 in.	64.0
10 ft. 0 in. to 11 ft. 11 in.	13.0	56 ft. 0 in. to 57 ft. 11 in.	66.0
12 ft. 0 in. to 13 ft. 11 in.	17.5	58 ft. 0 in. to 59 ft. 11 in.	67.5
14 ft. 0 in. to 15 ft. 11 in.	20.5	60 ft. 0 in. to 61 ft. 11 in.	69.5
16 ft. 0 in. to 17 ft. 11 in.	23.0	62 ft. 0 in. to 63 ft. 11 in.	71.5
18 ft. 0 in. to 19 ft. 11 in.	25.0	64 ft. 0 in. to 65 ft. 11 in.	73.5
20 ft. 0 in. to 21 ft. 11 in.	28.0	66 ft. 0 in. to 67 ft. 11 in.	74.5
22 ft. 0 in. to 23 ft. 11 in.	31.5	68 ft. 0 in. to 69 ft. 11 in.	76.0
24 ft. 0 in. to 25 ft. 11 in.	34.5	70 ft. 0 in. to 71 ft. 11 in.	77.5
26 ft. 0 in. to 27 ft. 11 in.	37.5	72 ft. 0 in. to 73 ft. 11 in.	79.0
28 ft. 0 in. to 29 ft. 11 in.	40.0	74 ft. 0 in. to 75 ft. 11 in.	81.0
30 ft. 0 in. to 31 ft. 11 in.	42.0	76 ft. 0 in. to 77 ft. 11 in.	84.0
32 ft. 0 in. to 33 ft. 11 in.	44.0	78 ft. 0 in. to 79 ft. 11 in.	85.5
34 ft. 0 in. to 35 ft. 11 in.	46.5	80 ft. 0 in. to 81 ft. 11 in.	87.5
36 ft. 0 in. to 37 ft. 11 in.	48.5	82 ft. 0 in. to 83 ft. 11 in.	89.0
38 ft. 0 in. to 39 ft. 11 in.	50.0	84 ft. 0 in. to 85 ft. 11 in.	91.0
40 ft. 0 in. to 41 ft. 11 in.	52.0	86 ft. 0 in. to 87 ft. 11 in.	93.0
42 ft. 0 in. to 43 ft. 11 in.	54.0	88 ft. 0 in. to 89 ft. 11 in.	95.0
44 ft. 0 in. to 45 ft. 11 in.	55.5	90 ft. 0 in. to 91 ft. 11 in.	98.0
46 ft. 0 in. to 47 ft. 11 in.	57.5	92 ft. 0 in. to 93 ft. 11 in.	100.0

The Effect of the Application of Cold Produced by Ice Packs and Heat Produced by the Infra-red Ray on the Activity of the Intact Muscle of the Human

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OWING to the rather extensive use of cold applications and heat produced by the infra-red lamp as means of altering the condition of human muscle, it appeared desirable to have objective data relative to the effects of such procedures. It was the purpose of this investigation to determine just what the effects of the application of heat or cold was on the activity of the intact muscle of the human.

When a muscle is stimulated by a single stimulus it responds by a single contraction. This type of response is designated as muscular contraction and consists of three phases as follows:

1. *The Latent Period.*—During this period there is no apparent change in the muscle. It represents the time required for the initiation of the movement.

2. *The Period of Contraction.*—This is the period of shortening, sometimes called the period of increasing energy.

3. *The Period of Relaxation.*—This period represents the time required for the muscle to return to its resting state after contraction and is sometimes designated as the period of decreasing energy.

The sum of these three phases is referred to as the total period of response.

In order to determine the effects of alteration in external temperature upon the activity of intact muscle the time required for the completion of the periods of contraction just described was measured before and after the application of heat or cold to the muscle.

Since an experiment of this nature must necessarily be limited to a single muscle or muscle group the gastrocnemius was selected. This particular choice was made since this muscle lends itself to experimentation of this type better than any other.

REVIEW OF LITERATURE

An examination of the literature yielded but little data having a direct bearing on the problem considered here. However, Tuttle and Williams*[1] studied the effects of auto-condensation and high frequency electric currents on the tonus of skeletal muscle. Their method of approach was to compare the extent of the knee-jerk before and after the application of the currents. It was found that when auto-condensation current was applied for a sufficient time to produce perspiration, the extent of the knee-jerk was materially reduced. This was interpreted as meaning that there was a loss of tonus due to the relaxation of the muscle. In the case of the high frequency current it was found that when it was applied sufficiently to cause an irritation of the skin the extent of the knee-jerk was increased thus indicating an increase in muscle tonus.

Considerable research has been done relative to the length of the normal latent period of the intact gastrocnemius muscle of the human as recorded by the movement of the foot. On the basis of 9,267 experiments on 28 subjects, Royal[2] found that the mean normal latent period of the gastrocnemius muscle of man was .024 second, the range being .021 to .027 second. Affre[3] found that the mean of 11,552 experiments on 25 subjects was .026 second, the range being .020 to .031 second. Wendler,[4] using 2,272 experiments on 25 subjects as a basis for calculation, found that the mean latent time was .025 second, the range being .017 to .029 second. It seems quite well established that the latent time of the intact gastrocnemius muscle of the human is about .025 second.

A technique was developed for measuring the periods of contraction of the intact gastrocnemius muscle of the human and is described.

TECHNIQUE

In adopting a technique for measuring the latent time, contraction time, and relaxation time, of the intact human skeletal muscle, advantage was taken of the fact that by applying an electrical stimulus to the motor point of a skeletal muscle a contraction of the muscle in question was elicited.

The response of the gastrocnemius muscle was elicited by applying a submaximal induction shock to the medial motor point of the muscle. The medial motor point was selected rather than the lateral, because when it was stimulated the movement of the foot was mainly downward rather than to the side.

Stimulating Unit.—The arrangement of the apparatus for applying the stimulus is shown in Figure 1. It consisted of an inductorium, the primary of which was in series with two dry cells, and a foot switch. The secondary terminated in two electrodes, *A* and *B*, Figure 1, one of which was a brass plate two inches by one inch, and the other a copper ball

* Numbers refer to bibliography at end of article.

one-fourth inch in diameter. Both electrodes were covered with gauze which was kept moist with a saturated saline solution. The brass plate was strapped to the thigh, care being taken to avoid any motor points. The stimulating electrode was held in place over the medial motor point of the gastrocnemius muscle by a strap going around the leg. The motor point in question was located before adjusting this electrode. In each case submaximal stimuli of uniform intensity were applied. In most cases the

Fig. 1.

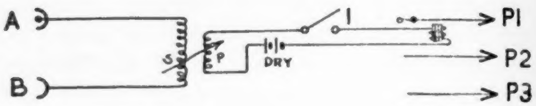

Fig. 2.

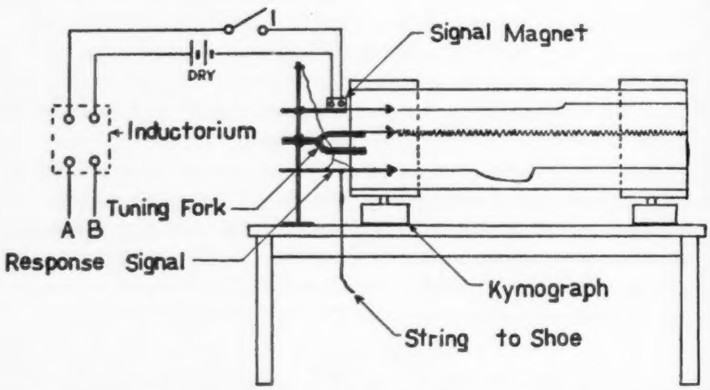

FIGURE 1.—The arrangement of the apparatus for delivering break stimuli to the intact gastrocnemius muscle of the human. *A*, lower contact to leg; *B*, upper contact to leg; *I*, switch; *P1*, signal magnet; *P2*, tuning fork; and *P3*, response stylus.

FIGURE 2.—The arrangement of the apparatus for recording the response of the intact gastrocnemius muscle of the human.

break stimulus was below the threshold for the make. When the make stimulus was adequate, it did not interfere since the key was closed and held down, the break alone being recorded.

Recording Device.—The beginning of the overt response was recorded by a stylus suspended from a rubber band and connected over pulleys to the toe of the subject's shoe. The arrangement of the recording device is shown in Figure 2. The subjects lay on a table (thirty-one inches from the floor) in a prone position, the right foot extending well over the edge of the table. Care was taken that the tension on the muscle, due to the rubber band, was kept constant for each reading. The time

of the application of the stimulus was recorded by a signal magnet in series with the primary of the inductorium. The signal magnet stylus was always superposed over the stylus which recorded the beginning of the response. Between the signal magnet and response stylus, and in line with them, a one hundred d.v. electrically driven tuning fork was placed.

The records were made on an extension kymograph drum, which made it possible to record from forty to fifty complete responses during one complete turn. As soon as the records were finished they were "fixed" and hung up to dry.

When all was in readiness, the experimenter stood in such proximity to the apparatus that she could reach the recording apparatus with her hands and the stimulating apparatus with her foot. Without warning the subject, the experimenter, after having closed the foot switch, began spinning the drum and an instant later opened the stimulating switch which activated the muscle. Since all recording apparatus was superposed, the speed with which the kymograph was turned was immaterial except that care was taken to turn it fast enough so that the distance between tuning fork vibrations was easily read to the third decimal place.

A typical record is shown in Figure 3. The record of the signal magnet is at the top, and the record of the response at the bottom of the figure, and thus they read from right to left. This arrangement was used because it eliminated a number of pulleys and made the apparatus more simple. However, the completed records were turned so that they read from left to right.

The instant the stimulus was given is indicated by a break in the signal magnet line, and the time of the beginning of the response is shown by the place where the response stylus leaves the base line. In order to determine the time elapsing between the stimulus and the response, and the end of response, ordinates were dropped from the break in the signal magnet line from the point where the response stylus left the base line and from the point where the stylus returned to the base line (lines *A*, *B*, and *D* in Figure 3). The time elapsing between the beginning and the end of response was divided into contraction time (*B-C*, Figure 3); relaxation time (*C-D*, Figure 3), by determining the center of the highest point of the curve by means of a ruler held on the response line and parallel to the base line. Time was read in .01 second. From crest to crest was regarded as .01 second, and from crest to trough, .005 second. Where the ordinates fell between crest and trough the fraction was estimated to the nearest thousandth second.

Application of the Infra-red Ray.—In order to determine the effect of heat on the intact muscle, an infra-red light (fifty-eight inches from the floor), which had been turned on for at least ten minutes previous to the beginning of the experiment, was placed directly above the gastrocnemius muscle of the subject. Time was recorded from the instant the

light was applied. It was our purpose to apply the light to the muscle over a period of time comparable to that of the usual treatment, an attempt being made to duplicate the therapeutical technique.

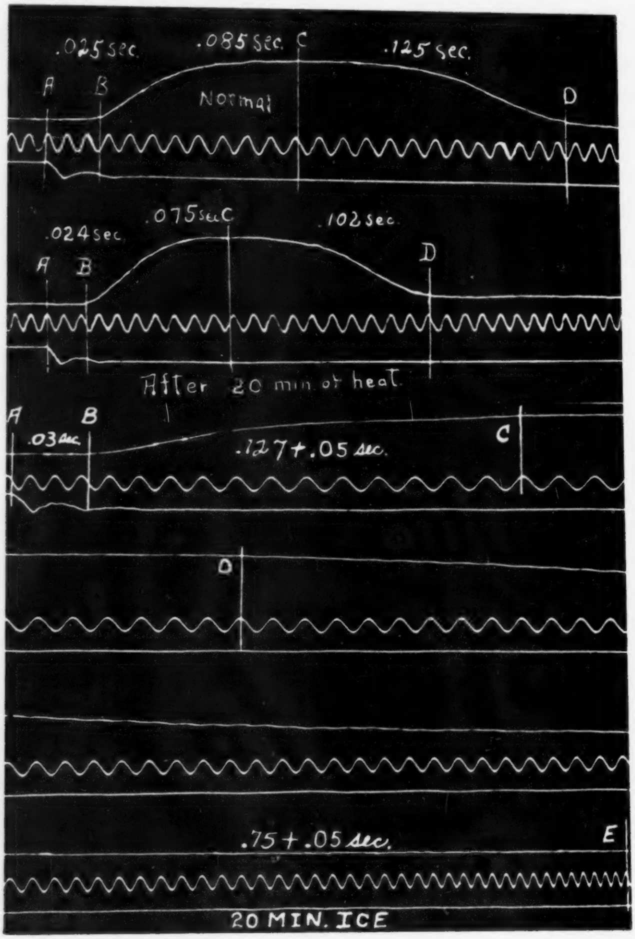

FIGURE 3.—A typical record of the effect of intra-red ray and ice applied to the intact gastrocnemius muscle of the human. During .1 second, in the record on the effect of cooling, the muscle remained in a state of contraction; .05 second of this time was added to the period of contraction and .05 second to the period of relaxation.

Application of Ice.—In order to cool the muscle, ice was applied to it. This was done by means of a receptacle made from sheet iron. It was approximately as long as the leg and had U-shaped openings in each end

to fit the leg. The top was open. The leg was placed in the receptacle and then covered with cracked ice.

THE DATA

Data were collected from twenty-four subjects in the experiment involving cooling, and from twenty-five subjects involving heat. They were all women between the ages of eighteen and twenty-five years. The procedure was to record ten or twenty normal responses. After this the heat or cold, according to the experiment, was applied for twenty minutes and a second set of readings was taken. Since it was found that ten records gave a reliable mean, the number of readings was set at not less than ten.

Since the muscular contraction was studied according to the periods of contraction the data are presented from this standpoint.

Latent Period of Contraction.—The raw data* are omitted from this discussion. The mean normal latent time of the group before heat was applied to the muscle was .029 ± .004 second. After the application of heat to the muscle for a period of 20 minutes this time became .026 ± .003 second. The obtained difference was .003 ± .001 second. The data showed that in 16 cases the mean time was shorter while in 9 cases it was longer.

The mean normal latent time of the group before ice was applied to the muscle was .024 ± .002 second. After the muscle had been exposed to an ice pack for 20 minutes, this time became .033 ± .003 second. The obtained difference was .009 ± .0007 second. The data showed that the latent time was longer in every case.

Period of Contraction.—The mean normal contraction time of the group before heat was applied was .103 ± .013 second. After heat had been applied to the gastrocnemius muscles of these individuals for 20 minutes the period of contraction became .090 ± .009 second. The obtained difference was .013 ± .003 second. In 19 cases the period of contraction became shorter while in 6 cases it was longer.

The mean normal contraction time of the group before the muscle was cooled was .089 ± .006 second. After cooling this time became .162 ± .002 second. The obtained difference was .073 ± .001 second. In every case cooling increased the periods of contraction.

Period of Relaxation.—The mean normal relaxation period of the group before heat was applied to the gastrocnemius muscle was .177 ± .035 second. After the application of heat by the infra-red ray this time became .168 ± .032 second. The obtained difference was .009

* The raw data are contained in the two M.A. Theses: D. Denkmann, The Effect of External Temperature Changes as Brought About by Infra-red Radiation on the Response of the Intact Human Gastrocnemius Muscle, July, 1933; T. M. Kenefick, A Study of the Effect of the Application of Cold to the Intact Gastrocnemius Muscle of the Human, June, 1933. These are on file in the library, State University of Iowa, Iowa City, Iowa.

$\pm$ .009 second. An examination of the individual data showed that in 13 cases the time was shorter while in 12 it was longer.

Before ice was applied to the muscle, the mean normal relaxation time of the group was .267 $\pm$ .034 second. After the application of the ice this time became .726 $\pm$ .061 second. The obtained difference was .459 $\pm$ .014 second. Here again the cooling of the muscle caused an increase of the relaxation time in every case.

Total Period of Response.—Before heat was applied the mean normal total time involved in the contraction of the gastrocnemius muscle was .308 $\pm$ .042 second. This became .292 $\pm$ .034 second after the application of the infra-red ray. The obtained difference was .016 $\pm$ .012 second. The individual data showed that in 6 cases the time was longer and that in 19 cases the time was shorter after the application of heat.

Before ice was applied the mean normal total time involved in the contraction of the gastrocnemius muscle was .381 $\pm$ .057 second. This time became .932 $\pm$ .070 second after the muscle was cooled. The obtained difference was .631 $\pm$ .018 second. An individual analysis showed that in every case the time was increased by cooling the muscle.

SUMMARY AND CONCLUSIONS

In general, the application of heat produced by infra-red ray and cold—produced by ice—to the intact gastrocnemius muscle, caused effects similar to those obtained when excised muscle tissue was used.

1. Cooling produced by ice packs caused a decided increase in the total contraction time, as well as all the phases of contraction, of the intact gastrocnemius muscle.

2. Heating produced by infra-red ray showed a tendency to decrease the periods of contraction as well as the total contraction time of the gastrocnemius muscle. The difference between the length of the normal response and the length of the response after the muscle had been heated by the infra-red ray was small and can only be interpreted as showing a tendency toward effectiveness, as far as muscular contraction is concerned.

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A Study of Collateral Readings For Use in the Teaching of Health[1]

(Mental and Social Hygiene)

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HEALTH was placed first among the seven educational objectives in the Cardinal Principles of Secondary Education fifteen years ago. Although actual practice within the existing school program has not given it a position of corresponding prominence, the importance of health education is being recognized more widely each year. Within the field of health, mental and social hygiene have come into prominence recently as emphasis has shifted to newly recognized needs. Mental hygiene today is concerned with those factors in life which contribute toward or impede the health of the mind and emotions. Social hygiene (used here in its popular connotation) includes those personal and social problems of human living which arise from misunderstandings and abuse of the sex instinct. Whether one accepts the theories of Freud or not, one cannot deny the close inter-relationship between mental and social hygiene.

COLLATERAL READINGS IN MENTAL AND SOCIAL HYGIENE

The values of collateral readings as a supplement to other phases of the educational process have been recognized for some time. Through this channel we seek to influence attitudes and to stimulate the development of desirable habits, as well as to increase factual knowledge. In health education the cultivation of desirable attitudes is a paramount factor and a prerequisite to the formation of desirable habits. Hence, collateral readings are of utmost importance in this field. Textbooks of health have frequently omitted or developed inadequately the subjects of mental hygiene and social hygiene. In general, teachers' preparation in these phases of health has been meager. Collateral readings cannot restore the integrity of an otherwise defective teaching program, but with proper direction they have a definite contribution to make to that program.

[1] This thesis reports the investigation of 149 books and pamphlets as source material for health education; 62 in the field of mental hygiene, 87 in social hygiene. The study was undertaken at the suggestion of Dr. A. V. Hardy, of the Department of Hygiene and Preventive Medicine, State University of Iowa.

CRITERIA

In our survey of mental and social hygiene, the following points in literature, to be used in the teaching of health, are considered:[2]

1. The material shall be scientific, or, where scientific facts are lacking, authoritative. Prejudices, exaggerations, and opinions, stated as facts, shall be avoided. The author must be a master of his subject.

2. The material shall be adapted to the group for which it is intended. It must meet their needs and arouse their interests. The mechanics of presentation shall be appropriate to the educational level of the group.

3. The material shall lead to the achievement of established objectives. The phases taken up shall be handled adequately and the development of attitudes shall be given equal importance with the presentation of facts. It shall stimulate reactions and develop mental and social hygiene consciousness.

4. Stress shall be placed upon the development of the normal, rather than the prevention of the abnormal, or the correction of the pathological. Emphasis shall rest upon the attainment of control over normal processes.

5. There shall be no undue usage of technical terms but in all cases they should be most definite and expressive.

6. The style shall be clear, sincere, vigorous, pleasing, and adapted to the group. The emotional tone must be well balanced.

7. The edition shall be comparatively recent.

8. The publisher shall be reliable.

9. The form of composition, i.e., diction and phrasing, shall be satisfactory.

10. The mechanics of printing shall be attractive, readable, and technically correct.

OBJECTIVES FOR COLLATERAL READING MATERIAL

The objectives to be achieved through collateral reading shall be in harmony with the aims of education, definite, capable of achievement, and adapted to the group for which they are being prepared. The objectives for collateral readings in mental and social hygiene will vary with the group under consideration. Our interest in the preadolescent and adolescent periods lies chiefly in the individual himself, that he may know and apply those principles which constitute the foundation of health. As we consider the young adult (a potential parent), the teacher, and the parent, we must add knowledge concerning the application of

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[2] These are an adaptation of items from the following sources:

a. P. S. Achilles, *The Effectiveness of Certain Social Hygiene Literature*, p. 21. New York: Amer. Soc. Hyg. Assoc., 1923.

b. J. Pinckney, *Principles and Practices in Health Education*, p. 207. New York: Amer. Child Health Assoc., 1932 (Health Educ. Conf. 1930).

c. C. M. Turner, *Principles of Health Education*, pp. 236-239. Boston: D. C. Heath & Co., 1932.

those principles which are outside the realm of self. They should not apply alone to child life with which he may come in contact. A study of objectives in mental and social hygiene and health education from various sources[3] preceded the establishment of the objectives listed.

CLASSIFICATION AND EVALUATION OF MATERIAL

The opinions of experts in mental hygiene, relative to the authority of certain authors in that field, were available and taken into consideration. The classification and evaluation of the literature were largely subjective and based entirely upon their contributing value in the achievement of our definite objectives, irrespective of their value in the field in general. For this reason some very excellent material both in mental and social hygiene has not been recommended. Only a limited number of those books and pamphlets which contribute most to the attainment of each objective are included here.

OBJECTIVES FOR COLLATERAL READINGS IN MENTAL HYGIENE WITH RECOMMENDED LITERATURE

I. Objectives for the high school level:

A. To give a basic appreciation of the significance of mental health.

1. Andress, J. M., Aldinger, A. K., and Goldberger, J. H. *Health Essentials*. Boston: Ginn & Co., 1928. Ch. VI, "A Healthy Mind," pp. 74–85.
2. Andress, J. M., and Brown, M. A. *Science and the Way to Health*. Boston: Ginn & Co., 1930. Ch. XIX, "Mental Health and How to Get It," pp. 296–306.

B. To create a wholesome attitude toward mental illness. (No suitable material was found.)

C. To aid in the recognition of everyday habits conducive to mental health and to encourage their development.

1. Elliott, G. L. *Understanding the Adolescent Girl*. New York: H. Holt & Co., 1930. Pp. 129.
2. Hollingworth, L. S. *The Psychology of the Adolescent*. New York: D. Appleton & Co., 1928. Pp. 227.

II. Objectives for the college level:

A. To give a broad appreciation of the personal and community significance of mental health.

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[3] *a*. M. A. Bigelow, *Principles and Practices in Health Education*, pp. 23-28, 104-106. New York: Amer. Child Health Assoc., 1932 (Health Educ. Conf. 1930).

b. W. H. Burnham, *The Normal Mind*, pp. 641–673. New York: D. Appleton & Co. 1924.

c. T. D. Wood and H. G. Rowell, *Health Supervision and Medical Inspection of Schools*, pp. 540–546. Philadelphia: W. B. Saunders & Co., 1927.

d. A. H. Wood, The Biologic Basis of Mental Hygiene, pp. 18–20. Iowa City: Mimeograph class notes, 1932–33.

e. W. F. Snow, (Ch.) *Social Hygiene in Schools* (White House Conf. on Child Health and Protection), pp. 21–25. New York: The Century Co., 1932.

f. T. W. Galloway, *Sex and Social Health*, pp. 222–224. New York: Amer. Soc. Hyg. Assoc., 1924.

1. Burnham, W. H. *The Normal Mind.* New York: D. Appleton & Co., 1924. Ch. II.

2. Groves, E. R., and Blanchard, P. M. *Introduction to Mental Hygiene.* New York: H. Holt & Co., 1930. Pp. 467.

B. To create a wholesome attitude toward mental illness.

1. Beers, C. W. *A Mind That Found Itself.* Garden City, New York: Doubleday, Doran & Co., 1930. Pp. 394.

2. Williams, F. E. *Mental Hygiene.* Boston: Little, Brown & Co., 1929. Pp. 41.

C. To aid the individual in understanding the principles fundamental to mental hygiene and to stimulate their application in daily life.

1. Burnham, W. H. *The Normal Mind.* New York: D. Appleton & Co., 1924. Ch. XX.

2. Burnham, W. H. *The Development of the Wholesome Personality.* New York: The Nat'l Com. for Ment. Hyg., 1930. Ch. I, II and III. (Reprint from *Ment. Hyg. Bul.*) Pp. 9.

3. Fishbein, M., and White, W. A. *Why Men Fail.* New York: Century Co., 1928. Pp. 344.

4. Rees, J. R. *The Health of the Mind.* London: Faber & Faber, 1929. Pp. 266.

5. Riggs, A. F. *Intelligent Living.* New York.: Doubleday, Doran & Co., 1929. Pp. 230.

6. Williams, F. E. *Social Aspects of Mental Hygiene.* New Haven: Yale Univ. Press, 1930. Pp. 150.

III. Objectives for the normal school (in addition to those listed under II):

A. To further the appreciation of the problems of childhood and youth as they affect mental health, and, B, to aid in the recognition of school situations requiring guidance in the application of mental hygiene.

1. Bassett, C. *The School and Mental Health.* New York: The Commonwealth Fund, 1931. Pp. 66.

2. Burnham, W. H. *Success and Failure as Conditions of Mental Health.* New York: The Nat'l. Com. for Ment. Hyg., 1932. (Reprint from *Ment. Hyg.*) Pp. 12.

3. Crawford, N. A., and Menninger, K. A. *The Healthy Minded Child.* New York: Coward-McCann, Inc., 1930. Pp. 198.

4. Richards, E. L. *Behavior Aspects of Child Conduct.* New York: The Macmillan Co., 1932. Pp. 288.

5. Sayles, M. B. *The Problem Child in School.* New York: The Commonwealth Fund, 1925. Pp. 287.

6. Taft, J. *The Relation of the School to the Mental Health of the Average Child.* New York: The Nat'l. Com. for Ment. Hyg., 1923. (Reprint from *Ment. Hyg.*) Pp. 15.

7. Wickman, E. K. *Children's Behavior and Teachers' Attitudes.* New York: The Commonwealth Fund, 1929. Pp. 247.

8. Also material listed for parent education.

IV. Objectives for parent education (in addition to those listed under II):

A. To lead toward an appreciation of the problems of childhood and youth as they affect mental health, and, B, to aid in the recognition

of focal points within the home for the application of mental hygiene.

1. Elliott, G. L. *Understanding the Adolescent Girl.* New York: H. Holt & Co., 1930. Pp. 129.
2. Hohman, L. *The Formation of Life Patterns.* New York: The Nat'l. Com. for Ment. Hyg., 1928. (Reprint from *Ment. Hyg.*) Pp. 15.
3. Sayles, M. B. *The Problem Child at Home.* New York: The Commonwealth Fund, 1928. Pp. 285.
4. Thom, D. A. *Everyday Problems of the Everyday Child.* New York: D. Appleton & Co., 1927. Pp. 341.
5. Thom, D. A. *Normal Youth and Its Everyday Problems.* New York: D. Appleton & Co., 1932. Pp. 368.
6. Also material listed for the normal school.

OBJECTIVES FOR COLLATERAL READINGS IN SOCIAL HYGIENE WITH RECOMMENDED LITERATURE

I. Objectives for the high school level (preadolescent period):

A. To give an adequate knowledge of the facts of sex and reproduction.

1. de Schweinitz, K. *Growing Up.* New York: The Macmillan Co., 1928. Pp. 111.

B. To explain the physical and psychological changes which occur in both sexes and to further an appreciation of their significance in such a manner as to develop a wholesome attitude toward sex.

1. Dennett, M. W. *The Sex Side of Life.* Publ. by author, 1928. Pp. 27.

II. Objectives for the high school level (adolescent period):

A. To reinforce the objectives of the preadolescent period and to promote an appreciation of sex as a force capable either of enriching or of vitiating life.

1. Clapp, E. V. *Growing Up in the World Today.* Boston: Mass. Soc. for Soc. Hyg., 1932. Pp. 20.
2. Dickerson, R. E. *So Youth May Know.* New York: Assoc. Press, 1931. Pp. 255.
3. Elliott, G. L., and Bone, H. *The Sex Life of Youth.* New York: Assoc. Press, 1929. Pp. 146.

B. To create an appreciation and an anticipatory ideal of home and family life.

1. Edson, N. D. *Choosing a Home Partner.* New York: The Amer. Soc. Hyg. Assoc., 1925. Pp. 15.

III. Objectives for the college level:

A. To supplement deficient training during adolescence.

1. Eddy, S. *Sex and Youth.* London: Stud. Christ. Move., 1928. Pp. 150.
2. Elliott, G. L. *Sex as a Constructive Social Force.* New York: The Nat'l Com. for Ment. Hyg., 1930. (Reprint from *Ment. Hyg.*) Pp. 6.
3. Royden, A. M. *Sex and Common Sense.* New York: G. P. Putnam's Sons, 1922. Pp. 211.

B. To further the expectation of and preparation for happy marriage and parenthood.

1. Bigelow, M. A. *Biological Foundations of the Family*. New York: Amer. Soc. Hyg. Assoc., 1930. (Reprint from the *J. Soc. Hyg.*) Pp. 5.

2. Committee on Marriage and the Home. *Ideals of Love and Marriage*. New York: Com. on Church & Soc. Serv., Federal Council of Churches of Christ in Amer., 1932. Pp. 23.

3. Gray, A. H. *Men, Women and God*. New York: Assoc. Press., 1923. Pp. 189.

4. Groves, E. R. *Marriage*. New York: H. Holt & Co., 1933. Pp. 552.

C. To provide an adequate knowledge of sex as a factor in the adjustment of married life. (For persons about to be married.)

1. Butterfield, A. M. *Marriage*. Published privately. Obtained from S. Eddy, 347 Madison Ave., N.Y., 1929. Pp. 48.

2. Wright, H. *The Sex Factor in Marriage*. New York: Vanguard Press, 1931. Pp. 122.

IV. Objectives for the normal school (in addition to those for the college level):

A. To develop an appreciation of the following:

(1) The social hygiene movement.

1. Bigelow, M. A. *The Established Points in Social Hygiene Education*. New York: Amer. Soc. Hyg. Assoc., 1933. (Reprint of *J. Soc. Hyg.*) Pp. 15.

2. Exner, M. J. *Progress in Sex Education*. New York: Amer. Soc. Hyg. Assoc., 1929. (Reprint of *J. Soc. Hyg.*) P. 16.

3. Exner, M. J. *What Is Social Hygiene?* New York: Amer. Soc. Hyg. Assoc., 1930. (Reprint of *J. Soc. Hyg.*) Pp. 12.

(2) The objectives of sex education at various levels.

1. Galloway, T. W. *Is There a Formula for Sex Education?* New York: Amer. Soc. Hyg. Assoc., 1932. (Reprint of *J. Soc. Hyg.*) Pp. 6.

2. White House Conference on Child Health Protection. *Social Hygiene in Schools*. New York: The Century Co., 1932. Pp. 59.

(3) Opportunities within the school program for sex education and guidance.

1. Balliett, T. M. *Introduction of Sex Education into the Public Schools*. New York: Amer. Soc. Hyg. Assoc., 1928. Pp. 5.

2. Galloway, T. W. *Sex Character Education in Junior High School*. New York: Amer. Soc. Hyg. Assoc., 1929. Pp. 94.

3. Galloway, T. W. *Social Hygiene in Health Education for Junior High Schools*. New York: Amer. Soc. Hyg. Assoc., 1929. Pp. 31.

4. Wood, T. D. *The Teacher's Part in Social Hygiene*. New York: Amer. Soc. Hyg. Assoc., 1926. Pp. 20.

B. To provide material which will aid in the process of sex education and guidance (scientific terminology, biological facts, social principles).

1. All of the material listed under V, A and B, and VI, A.

2. Edson, N. D. *Training Youth for Parenthood*. New York: Amer. Soc. Hyg. Assoc., 1927. Pp. 15.

V. Objectives in parent education:

A. To aid marital partners in achieving a desirable adjustment to the sex instinct.

1. Wright, H. *The Sex Factor in Marriage.* New York: Vanguard Press, 1931. Pp. 122.

B. To stimulate a wholesome attitude toward sex, its possibilities and its problems.

1. Elliott, G. L. *Sex as a Constructive Social Force.* New York: The Nat'l. Com. for Ment. Hyg., 1930. (Reprint from *Ment. Hyg.*) Pp. 6.
2. Gray, A. H. *Men, Women and God.* New York: Assoc. Press, 1923. Pp. 189.

C. To show the need for an understanding of sex guidance for youth and the specific objectives at various age levels.

1. *The Boy Problem.* New York: Amer. Soc. Hyg. Assoc., 1920. No. 284. Pp. 30.
2. Galloway, T. W. *Is There a Formula for Sex Education?* New York: Amer. Soc. Hyg. Assoc., 1932. (Reprint from *Ment. Hyg.*) Pp. 6.
3. Gruenberg, B. C.; Exner, M. J.; and Richmond, W. *Sex Education.* New York: The Child Study Assoc. of Amer., 1930. Pp. 12.

D. To provide material which will aid in the process of sex education and guidance (in addition to that listed for teachers).

1. Brown, H. W. *Child Questions and Their Answers.* New York: Amer. Soc. Hyg. Assoc., 1920. No. 248. Pp. 16.
2. Gardiner, R. K. *Your Daughter's Mother.* New York: Amer. Soc. Hyg. Assoc., 1921. No. 319. Pp. 10.
3. Gruenberg, B. C. *Parents and Sex Education.* New York: Amer. Soc. Hyg. Assoc., 1923. Pp. 100.

ABSTRACTS OF RECOMMENDED LITERATURE

It is impossible to include here a description of all the literature listed above.[4] We have selected the most outstanding material representative of the best contributions for the various groups, adolescents, adults, teachers, and parents. These are briefly abstracted.

A. MENTAL HYGIENE ABSTRACTS

Bassett, C. *The School and Mental Health.* New York: The Commonwealth Fund, 1931. Pp. 66.

A superior presentation in which concrete examples illustrate the application of the principles of mental hygiene to the school situation. The opportunity and responsibility of the school in regard to the mental health of the child are stressed. Symptoms of maladjustment, approaches to the problem child, and factors which promote or retard mental health are discussed in detail. Carefully chosen case studies aid the reader to understand the fundamental principles of mental hygiene and

[4] Abstracts of all of the literature recommended as contributing toward any of the objectives are included in the following: L. Reckmeyer, A Study of Collateral Readings for Use in the Teaching of Health. M.A. Thesis, July, 1933. On file in the library of the State University of Iowa.

their effective application within the school program. As the name implies, this book is written primarily for the teacher, but in such a way that it will be interesting and useful to parents as well. The style of presentation is simple and the terminology non-technical.

Elliott, G. L. *Understanding the Adolescent Girl.* New York: H. Holt & Co., 1930. Pp. 129.

This careful analysis of the problems of the adolescent girl is the result of the author's own experiences with girls of this age. Causes of adolescent problems are differentiated from symptoms. The major adjustments which must be made during this period are studied carefully. The book offers much that will be of value in preventing and alleviating emotional tangles and is a distinct contribution to the mental hygiene of adolescence. The author writes in simple terms and thus makes her work of direct value to the adolescent child as well as to parents and teachers.

Groves, E. R., and Blanchard, P. M. *Introduction to Mental Hygiene.* New York: H. Holt & Co., 1930. Pp. 467.

This introductory textbook in mental hygiene is written for the college student. It adequately covers the many phases of mental hygiene. The authors are conservative and refuse to take sides on issues which are still in the controversial stage. The facts pertinent to both sides are presented and the reader is left to draw his own conclusions. The book provides an excellent and comprehensive source of information concerning mental hygiene for the layman.

Richards, E. L. *Behavior Aspects of Child Conduct.* New York: The Macmillan Co., 1932. Pp. 288.

The author's attitude is revealed in the following quotations: "Each parent, teacher, doctor, psychologist, social worker, and school nurse must get into the habit of thinking of the child's so-called misbehavior as misfitting or maladjustment, symptomatic of a wide range of causal factors." (Introduction, p. xiii.) "The more frequently we think of behavior as an aspect of health, and health as a component part of behavior, the easier it will be for us all to correct the tendency to judge conduct by interpreting behavior." (Introduction, p. xiv.)

This is one of the outstanding contributions to the literature for parents and teachers on the mental hygiene of childhood. Both content and presentation are scientific but non-technical. The author recognizes the fact that there is no "cure-all" for the problems of child conduct, but through presentation of case records seeks to show where some of these problems originate. Behavior and health, failure in adjustment, physical and mental handicaps, misfits in the school, fears, misdirected energy, and similar phases of mental hygiene are included. The need for cooperation between all agencies interested in the welfare of the child is stressed. Both teachers and parents may profit from this excellent book.

Thom, D. A. *Everyday Problems of the Everyday Child.* New York: D. Appleton & Co., 1927. Pp. 341.

The author has given us a very readable discussion of a comprehensive group of problems which arise in connection with the mental health of childhood. The need of discovering underlying motives when dealing with behavior problems is illustrated most clearly. Great emphasis is placed upon the possibilities arising from proper child training, and, as far as behavior is concerned, the influence of heredity is somewhat disparaged. Illustrative case studies are presented in connection with each type of problem. The book is exceptionally valuable for parents and teachers.

Wickham, E. K. *Children's Behavior and Teachers' Attitudes.* New York: The Commonwealth Fund, 1929. Pp. 247.

The author made a thorough experimental study of teachers' attitudes toward child behavior and then compared these with the attitudes of thirty mental hygienists. There is a serious indictment in the observation that behavior which is annoying to the teacher is classed as a problem while the unsocial forms of behavior, which mental hygienists consider more serious, are given scant consideration. The need of re-education in attitudes toward behavior and the recognition of types of behavior whose aim is the avoidance of social requirements are stressed. Not only teachers, but those responsible for the set-up of our educational program as well, should be familiar with this "effort to analyze prevailing attitudes toward behavior problems of children" (page 1), and should realize that "many kinds of behavior now regarded as undesirable are expressions of normal child activity, necessary for health development, but which conflict with adult standards of behavior" (page 59).

Williams, F. E. (Ed.) *Mental Hygiene.* Boston: Little, Brown and Co., 1929. Pp. 41.

The first twenty-six pages of this book provide a simple and very readable introduction to mental hygiene for the unacquainted layman. It answers the question, "What is mental hygiene?" and, following a brief discussion of ancient attitudes, gives a wholesome interpretation of mental illness. The danger of misinformation concerning mental hygiene is disclosed and five recommended books on the subject are discussed.

B. SOCIAL HYGIENE ABSTRACTS

Balliett, T. M. *The Introduction of Sex Education into the Public Schools.* New York: Amer. Soc. Hyg. Assoc., 1928. Pp. 5.

The meaning of sex education, underlying principles, administrative problems, and some suggestions are presented briefly but effectively. The pamphlet is highly recommended to administrators and teachers.

Bigelow, M. A. *The Established Points in Social Hygiene Education.* New York: Amer. Soc. Hyg. Assoc., 1933. (Reprint from *J. Soc. Hyg.*) Pp. 15.

The author reviews briefly the social hygiene movement up until 1933 and states the aims and objectives. The review will aid in the understanding and appreciation of social hygiene and is recommended especially for teachers.

Butterfield, O. M. *Marriage: Some Practical Suggestions for Happy Married Living.* Published privately. Distributed by S. Eddy, 347 Madison Ave., New York, 1929. Pp. 48.

Social, economic, and biological tests which arise in marriage are dealt with briefly, but helpfully. The sex side of marriage, its place, and its problems are given careful and adequate consideration and some suggestions ventured. The author is exceptionally frank in his discussion and thus provides an excellent source of much needed information for those who are soon to be married. The pamphlet is recommended also to those couples who have not adjusted themselves successfully to the new relationships of marriage.

Clapp, E. V. *Growing Up in the World Today.* Boston: Mass. Soc. for Soc. Hyg., 1932. Pp. 20.

Both the physical and psychological changes of adolescence are described and

their meaning interpreted. The relationship between maturity in mind and emotions and physical maturity is shown clearly. A frank and unemotional discussion deals with the problem of control of the sex instinct and the results to the individual and to society of various lines of conduct.

This pamphlet provides excellent guidance for adolescents and should be available early during this period. It will also be found useful for older students who have failed to receive a scientific background for the formation of a wholesome attitude toward sex.

de Schweinitz, K. *Growing Up—The Story of How We Became Alive, Are Born, and Grow Up*. New York: The Macmillan Co., 1928. Pp. 111.

This story of reproduction in plant, animal, and man is straight-forward, unemotional, scientific, but not technical. It stresses the fact that "being born" is not a unique experience but one through which we all pass. Although the presentation is adapted to the abilities of a child of eight or nine, the book is of greater value as an aid to parents and teachers in answering the earlier questions of the child concerning sex. The book is recommended as the best in its class.

Eddy, S. *Sex and Youth*. London: Stud. Christ. Move., 1928. Pp. 150.

The author handles the subject of sex in its various relationships to life in an excellent manner. The author has come into close contact with the problems of college students and the book is written especially for them. A frank discussion of various types of sex behavior and their temporary and permanent rewards contributes more toward the development of ideals in harmony with conventional standards than any hard and fast rules of conduct could possibly do. The problems of marriage and the family (as related to sex) are examined and their solution discussed. Questions relative to companionate marriage, the best age for marriage, relationships during the engagement period, and prostitution and veneral disease are considered in a most helpful manner. The book is highly recommended for college students to aid them in "thinking through" their standards of sex conduct.

White House Conference on Child Health and Protection. *Social Hygiene in Schools*. New York: The Century Co., 1932. Pp. 59.

The report of this subcommittee of the White House Conference on Child Health and Protection provides the best material available in regard to sex education in the school. Problems, principles, and methods are taken up first. Here comprehensive objectives for each age level are set up and the educational procedure for achieving these objectives outlined. The functions and interrelationships of home, school, church, and other social groups in this sex education program are designated. Social, legal, medical, and economic measures which relate to the problem of social hygiene are mentioned briefly. An annotated bibliography of helpful books and pamphlets is included. Every teacher in primary and secondary education should be familiar with this material.

Wright, H. *The Sex Factor in Marriage*. New York: Vanguard Press, 1931. Pp. 122.

A reviewer (W. F. Mengert, *Ment. Hyg.*, XVI (1932), p. 337) of this book has called it a "primer in sex." To quote him further, "In this description the author has given a very clear and readable exposition of the various factors and practices that are too often overlooked by married couples, who, either from a false sense of shame, or from pure ignorance, fail to realize that sexual intercourse requires both knowledge and practice in order to be consumated satisfactorily."

The book deals unreservedly and in plain language with various phases of the sex relationship in marriage: the mental, physical, and spiritual phases of sex love, the sex organs, the sex act, difficulties, elements which influence satisfaction, frequency, and sublimation. A wider dissemination among married couples of the information contained herein would tend to decrease the unhappiness, the inconstancy, and the nervous disorders which arise from a misunderstanding of the nature of the sex act.

SUMMARY

On summarizing the results of this study we realize that mental hygiene has provided an attractive subject for writers during the past decade. The literature was plentiful but, to a great extent, doubtful. It was difficult to find scientific accuracy combined with non-technical presentation. Overpopularization was encountered frequently. The best material dealt with mental hygiene in childhood and was prepared for teachers and parents.

Much of the social hygiene literature covered is now obsolete due to our changing attitudes towards sex and sex education. Inaccuracy prevails when opinions and prejudices have been expressed with little regard for scientific accuracy. However, there was some material which was excellent, especially for the high school level. Literature dealing with the physical relationships of marriage is available; some is especially good, some is trashy. The problem arises as to how to get this material to those for whom it is intended. Literature for teachers and parents relative to sex education exceeds the use which is being made of it.

RECOMMENDATIONS

The following recommendations have resulted from the study:

1. Collateral reading material should be used increasingly in health education.

2. Investigation of literature relative to health should be careful and continued.

3. Further consideration should be given to mental hygiene, especially at the high school level.

4. More accurate material should be provided in social hygiene and the available material utilized to a greater extent.

5. Further study should be made relative to the presentation of the sex hygiene in marriage.